ANALYSIS OF PRIMARY CARDIAC ARREST IN A METROPOLITAN AREA

by

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CHAPTER I

INTRODUCTION

Out-of-hospital cardiac arrest is a significant public health problem with a high incidence and ultimate mortality. Within the United States, the incidence is estimated to be 1 in 1,000 adults per year of which no more than one to three percent of the cases survive (Cummins, Ornato, Thies, & Pepe, 1991). More than 300,000 out-of-hospital cardiac arrest deaths occur annually.

Although sudden cardiac arrest is prevalent amongst all age groups and due to multiple causes, heart disease is the primary etiology in the vast majority of community cardiac arrests. Sudden cardiac arrest accounts for more than half of all coronary disease mortality in the United States and is the presenting manifestation of heart disease in nearly 50% of cases (Kramer & Schatzkin, 1985). The public health challenge is to reduce cardiac arrest mortality through prevention and successful prehospital resuscitation.

Successful resuscitation requires a multi-disciplinary emergency medical service (EMS) system response. Survival depends on a coordinated process beginning at the moment of arrest, through the prehospital phase, and into the hospital setting. Research in out-of-hospital cardiac arrest has identified certain time related components to be the most important factors associated with survival, specifically cardiopulmonary resuscitation (CPR) within four minutes and advanced life support therapies within eight to ten minutes (Eisenberg, Bergner, & Hallstrom, 1979b; Eisenberg, Bergner, & Hearne, 1980; Roth, Stewart, Rogers, &

Cannon, 1984). To accomplish this, there must be public awareness for early recognition of cardiac symptoms including arrest, early initiation of CPR, and the prompt and appropriate response of trained rescue personnel.

Limited information exists concerning out-of-hospital cardiac arrest in Portland. Knowledge of the epidemiology of cardiac arrest in Portland and the EMS response provides valuable information for identifying target populations who could benefit from focused cardiac arrest training programs and for evaluating the utilization of EMS services. As primary care providers, educators, and contributors to public policy, the nursing profession has a collaborative role in problem solving this public health problem. The purpose of this study is to provide a demography of the primary cardiac arrest population in metropolitan Portland and to assess the effectiveness of the EMS response to this population.

REVIEW OF THE LITERATURE

The review of the literature focuses on three content areas: (1) the epidemiology of cardiac arrest and sudden death (2) the factors associated with successful cardiac arrest resuscitation and survival, and (3) the importance of evaluating and reporting cardiac arrest outcome.

Epidemiology of Cardiac Arrest And Sudden Death

Cardiac arrest is defined as the cessation of cardiac mechanical activity, confirmed by the absence of a detectable pulse, unresponsiveness, and apnea (Cummins et al., 1991). Without intervention this state of clinical death eventuates in biological death within four to ten minutes. Sudden death is unexpected death

due to a cardiac etiology, the index event being cardiac arrest, within one hour of the onset of terminal symptoms (Myerburg, 1987).

More than 75% of out-of-hospital cardiac arrests are attributed to underlying cardiac disease (Becker, Ostrander, Barrett, & Kondos, 1991; Eisenberg, Bergner, & Hallstrom, 1979a; Eitel, Walton, Guerci, Hess, & Sabulsky, 1988; Roth et al., 1984). In the United States heart disease is the leading cause of death for persons ages 35-65, accounting for over 760,000 deaths annually, of which nearly 68% are attributed to coronary artery disease (Bureau of Census, 1989). Furthermore, over half of the deaths from coronary artery disease are sudden deaths (Kannel & Schatzkin, 1985) occurring in the home (Becker et al., 1991; Eisenberg, 1984; Guzy, Pearce, & Greenfield, 1983; Ritter et al., 1985).

The Framingham Heart Study (Dawber, 1980) serves as the primary epidemiological resource for identification of risk factors for coronary artery disease and sudden death in the United States. Age and male sex are associated with an increased risk of sudden death. Kannel and Schatzkin (1985) report that the incidence of sudden death doubles with each decade after age 45, and the proportion of coronary events presenting as cardiac arrest also increases with age. The overall incidence of sudden death in men is four times greater than in women and seven times higher in the 55-65 year old age group (Dawber, 1980). Investigations in out-of-hospital cardiac related cardiac arrest, referred to as primary cardiac arrest, reveal a 60-70% male composition with the median age being in the mid sixties (Eisenberg, Cummins, & Hallstrom, 1986; Eitel et al.,

1988; Guzy et al., 1983; Ritter et al., 1985; Spaite, Hanlon, Criss, Valenzuela, Wright, Keeley, & Meislin, 1990).

Although persons with established coronary heart disease are at an increased risk of cardiac arrest, the proportion of sudden deaths is substantially greater in persons without known cardiac disease than in those with overt coronary artery disease. Fifty percent of sudden deaths in men and 64% in women occur in the absence of known coronary disease (Kannel & Schatzkin, 1985). As age increases, the proportion of sudden deaths among all coronary artery disease deaths decreases.

Risk factors for sudden death are similar to those predisposing to coronary artery disease. By multivariate analysis, the Framingham research group found hypertension, hypercholesteremia, smoking, and the presence of abnormalities on the resting electrocardiogram to be significant risk factors for sudden death with glucosuria, cardiac enlargement, obesity, pulse rate, and ventricular ectopy having varying degrees of significance (Castelli, Levy, Wilson, Anderson, & Sanders, 1990). Combining risk factors improves the predictability for sudden death. Persons in the top decile of risk account for nearly half of the sudden deaths in men and women (Dawber, 1980).

Hinkle and Thaler (1982) reported that in a series of patients from whom death occurred within one hour, 93% were due to arrhythmias, primarily ventricular fibrillation (VF). The majority of primary cardiac arrests are associated with an initial rhythm of VF (Eisenberg, 1984; Eitel et al., 1988; Olson et al.,

1989; Roth et al., 1984; Ritter et al., 1985; Spaite et al., 1990; Tresch, Thakur, Hoffmann, & Brooks, 1988). To a much lesser degree, other presenting rhythms in cardiac arrest include: asystole, ventricular tachycardia (VT), bradyarrythmias, and electrical mechanical dissociation (EMD).

A small percentage of out-of-hospital cardiac arrests result from noncardiac entities. These include: trauma, poisonings, respiratory disorders, cancer, neurologic disease, gastro-intestinal disorders, and suicide. Cardiac arrest in children and young adults is mainly the result of noncardiac entities (Clinton, Macgill, Irwin, Peterson, & Lilja, 1984; Eisenberg, Bergner, & Hallstrom, 1983; Ng, Clinton, & Peterson, 1990). Asystole, profound bradycardia, and electrical mechanical dissociation appear to be the predominant presenting cardiac rhythms in noncardiac related cardiac arrests (Eisenberg et al., 1983). Limited published data exist related to survival from cardiac arrest of noncardiac etiology (Eisenberg et al., 1980; Eisenberg et al., 1990).

In summary, out-of-hospital cardiac arrest is primarily the result of a cardiac etiology, most commonly, coronary artery disease. Males have the highest incidence with a median age in the mid sixties. The majority of primary cardiac arrests occur in the home. Ventricular fibrillation is the most common presenting cardiac rhythm.

Factors Related To Survival In Cardiac Arrest

The studies investigating primary cardiac arrest have examined several variables for the relationship to survival from cardiac arrest. Hearne and Cummins

(1988) have categorized the variables into fate and program factors. Fate factors are those variables related to the individual or to chance occurrence over which there is little control. Examples investigated include: age and gender, previous medical condition, presenting cardiac rhythm, and whether the arrest is witnessed or nonwitnessed. Program factors are intervention determinants influenced by the design and operation of the EMS system. Factors investigated include: access to the EMS system, bystander initiated CPR, the type of EMS response, and the time intervals to basic life support (BLS) and advanced life support (ALS). Both fate and program variables are presented.

Fate Factors

Age and gender.

Several researchers found that age was not correlated with the success or failure of prehospital resuscitation (Eisenberg, 1984; Eitel et al., 1988; Hallstrom, Cobb, Swain, & Messinger, 1985; Longstreth, Cobb, Fahrenbruch, & Coppass, 1990; Ng et al., 1990; Tresch et al., 1988). Tresch and co-workers (1988) compared cardiac resuscitation and survival in individuals ages 30-70 with individuals over age 70. Of 1,345 cardiac arrests, 403 individuals were successfully resuscitated, meaning the subjects had a return of spontaneous circulation, and were admitted to the hospital. While age was not significant in the immediate resuscitation, age was significant for survival to discharge from the hospital. Of the 175 persons who were discharged alive from the hospital, 67% were under the age of 70. Longstreth and co-workers (1990) noted similar results

in a related study. Eitel and colleagues (1988) found no relationship between age and survival from cardiac arrest.

In contrast, Murphy, Murray, Robinson, and Campion (1989) examined 244 subjects of cardiac arrest over age 70, of which two (0.8%) survived, and concluded that resuscitation in the elderly is rarely effective. This study lacked a comparison group making the specific influence of age on outcome in that sample questionable.

Ng and associates (1990) investigated the pediatric and young adult population and found no significant age-related differences in either the initial success of resuscitation or the probability of long term survival. Eisenberg and co-workers (1983) found a higher mortality rate in children than in adults but noted the probability that confounding variables had influenced the outcome.

Interestingly, gender has not been found to be correlated in the success of the initial resuscitation or survival from cardiac arrest (Eisenberg, 1984; Halstrom et al., 1985).

Previous medical history

Few studies have examined the individual's past medical history as a prognostic indicator for survival from cardiac arrest. Hallstrom and colleagues (1985) investigated the medical history in patients resuscitated following a witnessed arrest with a presenting rhythm of VF and noted a correlation between congestive heart failure and hospital mortality. However, there was no association between histories of myocardial infarction, angina, or hypertension and survival.

In a study by Weaver, Lorch, Alverez, and Cobb (1976), no association was found between the severity of coronary atherosclerosis and survival from cardiac arrest.

Eisenberg, Cummins, and Hallstrom (1985) retrospectively compared patients with and without symptoms prior to their cardiac arrest. The presence or absence of symptoms was strongly associated with survival; persons experiencing symptoms (e.g., chest pain, shortness of breath, nausea, epigastric pain, jaw or neck pain, arm pain) prior to their cardiac arrest were half as likely to survive compared to those who were without symptoms prior to their cardiac arrest. The researchers concluded that the onset of symptoms prior to cardiac arrest was indicative of more severe underlying myocardial damage.

Presenting cardiac rhythm

Several researchers have found a positive correlation between an initial rhythm of VF or VT and survival from cardiac arrest (Bachman, McDonald, & O'Brien, 1986; Becker et al., 1991; Eisenberg et al., 1984; Eitel et al., 1988; Ritter et al., 1984; Roth et al., 1984; Spaite et al., 1990; Stueven et al., 1986; Tresch et al., 1988; Weaver et al., 1986). In an investigation of 1,066 cardiac arrests, of which 68 (6%) persons survived, Eitel and colleagues (1988) reported a significant difference in survival between those found in a rhythm of VF and those found in asystole (11% versus 2% respectfully). Longstreth and colleagues (1990) reported 24% of the 493 elderly patients whose initial rhythm was VF survived. Over a thirteen year period, Weaver and colleagues (1986) reported annual survival rates of 25% from primary cardiac arrest when the presenting rhythm was VF.

Enns, Tweed, and Donen (1983) demonstrated the deterioration of cardiac rhythm from VF/VT to asystole during Holter monitoring of patients when defibrillation is not available. Weaver and associates (1986) retrospectively reviewed 1,059 cardiac arrest victims found in asystole and noted only 1% survived. They concluded the presence of asystole, pulseless idioventricular rhythms, or other rhythms, may represent preterminal rhythms that have degenerated from VF because of lengthy delays to resuscitation.

Witnessed cardiac arrests

Several researchers have found a significant difference in survival if the arrest is witnessed than if it is not witnessed (Becker et al., 1991; Eisenberg et al., 1984; Eitel et al., 1988; Spaite et al., 1990). In a witnessed cardiac arrest, a bystander hears or sees the individual collapse. In a nonwitnessed arrest, the person is discovered after the collapse, therefore, the time of the collapse is unknown. Eitel and co-workers (1988) examined 454 cases of primary cardiac arrest with an initial rhythm of VF and found a 12% survival rate (n=382) in witnessed arrests compared to 6% (n=72) in nonwitnessed arrests. For other rhythms, the survival was poor regardless of whether the arrest was witnessed or not. In a rural study of 512 primary cardiac arrests, there were no survivors amongst the 229 unwitnessed cardiac arrests (Bachman et al., 1986). Cummins and colleagues (1985) compared witnessed arrests to nonwitnessed arrests, and found regardless of the interventions, survival in nonwitnessed arrests was

extremely low. They concluded that cardiac resuscitation measures are effective almost exclusively to the group of individuals who have witnessed arrests.

In summary, there has been considerable research investigating the relationship of fate factors to survival from cardiac arrest. The presence of VF and witnessed arrest are positive fate factors predictive for increased survival from cardiac arrest if resuscitation measures are implemented quickly. Increasing age, a history of congestive heart failure, or presence of symptoms prior to the arrest, are fate factors that have been found to be associated with a higher rate of hospital mortality in spite of a successful resuscitation.

Program Factors

This section reviews the investigations of EMS system interventions and the relationship to primary cardiac arrest survival. Cardiac arrest is a "time dependent" medical emergency that in the absence of intervention, death will occur within minutes. Program factors investigated include: access to the EMS system, bystander initiated CPR, type of emergency personnel response, and the time interval to BLS and ALS.

Access to system

The 911 telephone number is the access to EMS in most cities in the United States, streamlining calls to enable a more rapid dispatch of rescue personnel. Investigators in Minneapolis noted the percentage of callers who could activate the EMS system in less than a minute rose from 63% before implementation of the system to 82% afterward (Mayron, Long, & Ruiz, 1984).

Slovis, Carruth, Seitz, Thomas, and Elsea (1985) showed that a priority 911 dispatch system, based on decision paths from key questions, shortened the mean total response time for cardiac arrest calls by 3.8 minutes.

Bystander CPR

In the early 1960's Kouwenhoven and co-workers (1960) demonstrated the effectiveness of CPR to victims of cardiac arrest. This period of temporary support was effective in sustaining life until definitive care such as defibrillation, endotracheal intubation, and pharmacological therapies could be initiated.

The effectiveness of bystander CPR, CPR initiated by citizens, in cardiac arrest outcome has been examined by a number of investigators. In studies comparing bystander initiated CPR (early CPR) with CPR initiated by EMS personnel (delayed CPR), survival in the bystander CPR group were 7-22% greater than the delayed CPR group (Eisenberg et al., 1979b; Thompson, Hallstrom, & Cobb, 1979; Guzy et al., 1983; Ritter et al., 1985; Roth et al., 1984;). Cummins and Eisenberg (1985) speculated that the magnitude of difference in those studies were a reflection of variables controlled such as: rhythm only (Thompson et.al., 1979, Guzy et al., 1983), rhythm and EMS response times (Roth et al., 1984), rhythm, age, and response times (Eisenberg, et al., 1979; Ritter et al., 1985).

Cummins and colleagues (1985), controlling for age, sex, rhythm, response times of BLS and ALS units, and witnessed event, compared survival rates in patients who received bystander CPR with those who did not. In multivariate logistic regression analysis of 2,043 primary cardiac arrests, survival in the

bystander initiated CPR group was significantly greater than in the nonbystander CPR group (27% versus 13% respectively; $p < .01$). The researchers concluded that bystander CPR is a positive independent factor for survival from cardiac arrest. Additionally, they noted that bystander initiated CPR in persons with a rhythm of VF experienced even greater survival rates to support their hypothesis that early CPR improves survival by making VF easier to defibrillate. Cummins' group concluded that the benefit of early CPR exits in a narrow "window of effectiveness". It must be initiated within four to six minutes of collapse and ALS must be followed within ten to twelve minutes of the collapse in order to be effective. Succeeding investigations supported these findings (Becker et al., 1990; Eitel et al., 1988).

Two studies evaluating the impact of bystander CPR in communities with rapid EMS response times show conflicting results. In Milwaukee, with mean BLS and ALS response times of two and five minutes respectively, Stueven and collaborators (1986) found no difference in survival outcome in the bystander CPR group versus the nonbystander CPR group. In Tucson, with a BLS mean response of three minutes and an ALS mean response of five minutes, Spaite and colleagues (1990) found a significantly higher survival rate in the witnessed arrest bystander CPR group compared to the witnessed arrest nonbystander CPR group (20% versus 9% respectively).

Type of EMS response and time interval to BLS and ALS

The EMS system response can be single level or tiered. Three types of single level response systems include: the basic emergency medical technician (EMT) providing only BLS services, the EMT-D (an EMT trained in defibrillation), and paramedics who provide definitive ALS care. Two tiered response systems are: the EMT/paramedic response, in which the EMT provides a BLS first response followed by the paramedic; and the EMT-D/paramedic, in which the first responder is an EMT-D and the second responder is a paramedic (Eisenberg, Horwood, Cummins, Reynolds-Haertle, 1990).

In King County, Wa., Eisenberg and co-workers (1980) compared survival from out-of-hospital cardiac arrest in a single response area serviced by EMTs with a similar single response area serviced by paramedics and found significantly greater survival rates in the paramedic service area (22% versus 6%). The evident factor accounting for the difference in survival rates was the time interval to definitive care; 7.8 minutes in the paramedic group versus 26 minutes in the EMT group. They concluded that the type of EMS system (EMT versus paramedic) is largely a reflection of time to definitive care.

Eisenberg et al. (1979a) investigated the following time related variables in a series of 569 witnessed cardiac arrest cases in King County: (1) time from collapse to access of 911; (2) the response time of the first emergency vehicle; (3) the time from collapse to the initiation of CPR; (4) the time from collapse to the time of definitive care. There were 123 (22%) survivors. Each of the four time

components was significantly associated with survival. In multivariate analysis, time to initiation of CPR and time to definitive care were the most predictive of outcome. If CPR was initiated within four minutes and if definitive care was provided within eight minutes, 43% of the patients survived. If either time was exceeded, survival decreased precipitously. If both times exceeded eight minutes, survival was 3%. They concluded that the time interval to CPR and the time interval to definitive care are jointly important. Eitel and associates (1988) found qualitatively similar results in a related study in York and Adams County, Pa.; the survival rate was 18% when CPR was initiated within four minutes and ALS within ten minutes, 7% when CPR was within four minutes but ALS was late, 6% when CPR was late but ALS was within ten minutes, and only 3% survived when both CPR and ALS were late.

In Seattle, Weaver and colleagues (1986) looked at the importance of time intervals in their tiered response system with a mean response interval of three minutes for the first responder and six to seven minutes for the ALS response. In logistic regression analysis of 244 witnessed cardiac arrests with an initial rhythm of VF, both delay until CPR and the delay until defibrillation predicted mortality. Survival rates decreased three percent for each minute of delay until initiation of CPR and continued to fall four percent each minute during the period after initiation of CPR to delivery of the first defibrillatory shock. When CPR was begun within three minutes of collapse and the first shock delivered shortly thereafter, 70% of the subjects survived.

The importance of timely defibrillation of patients in VF led to studies investigating the effectiveness of the EMT-D. A four fold increase in survival was found in the single tiered EMT serviced King County after the addition of the EMT-D (Eisenberg et al., 1980). In their tiered response area, Eisenberg and co-workers (1984) noted that if paramedics arrived more than four minutes after the EMT's arrival, there was a two fold decrease in survival for victims found in VF. With the introduction of the EMT-D as the first response, the survival rate for persons in VF remained the same even if the paramedic arrived more than four minutes after the EMT-D.

The EMT and EMT-D first response has been compared in several areas. In a Minnesota rural area, the survival rate was 2.5% with EMTs only and 9.9% with the EMT-D (Bachman et al., 1986). When an EMT-D was added in certain Wisconsin communities, survival rates for cardiac arrest with VF rose from 4% to 11% (Olson et al., 1989). There is limited information regarding the benefit of an EMT-D first response in systems in which the paramedic response time is very short. In a review of cardiac resuscitation in 29 cities and the five EMS type systems, Eisenberg and colleagues (1990) concluded survival rates are lowest in single response systems and highest in tiered systems.

In summary, the positive association between bystander CPR, BLS (EMT CPR), ALS (defibrillation), and survival from primary cardiac arrest is well documented. Bystander CPR, BLS within four minutes, and ALS (specifically defibrillation) within eight to ten minutes appear to be the primary program factors

predictive for survival. Additionally, the 911 system and EMT-D, have been found to decrease the response times for therapies, thereby enhancing the chances for survival.

Evaluating and Reporting Cardiac Arrest Outcomes

Evaluating primary cardiac arrest outcomes are important for measuring system effectiveness, making inter-system comparison, and for enhancing the body of knowledge related to out-of-hospital cardiac arrest. Investigations of out-of-hospital cardiac arrest have found wide variability in survival outcome (Eisenberg et al., 1980; Eisenberg, Cummins, Damon, Larsen, & Hearne, 1990; Eisenberg, Horwood et al., 1990). Eisenberg and colleagues (1980) attributed the vast variability to a lack of uniform terminology, definitions, methodological inconsistencies, and variation in reporting survival outcome. They proposed a standardized approach in reporting survival with the denominator being witnessed primary cardiac arrest and an initial rhythm of VF. Investigators using this definition, reported survival outcomes of 12%-30% (Eitel et al., 1988; Roth et al., 1984; Spaite et al., 1990).

Ten years later Eisenberg, Cummins, and colleagues (1990) reviewed 74 cardiac arrest investigations and noted the continuation of inconsistent terminology and definitions being responsible for the broad range of survival rates from 2% to 44%. They proposed that two outcome measurements be reported: admission to hospital (defined as a six hour survival), and discharge alive from the hospital.

The denominator for these measurements would be witnessed primary cardiac arrest with a presenting rhythm of VF.

In 1991, an international task force developed a consensus document entitled "Recommendations for Uniform Reporting of Data From Out-of-Hospital Cardiac Arrest: The Utstein Style" (Cummins et al., 1991). The Utstein Style includes a template for gathering cardiac arrest data with a glossary of terms and outcomes to be reported. If implemented, the guidelines will: (1) enable better epidemiologic understanding of unexpected out-of-hospital cardiac arrest, (2) result in more consistent methods across studies permitting inter-system comparisons (3) permit intra-system evaluation and comparison and (4) enable large scale multi-center studies and data bases.

There has been only one investigation of cardiac arrest in Portland (Rose, 1974), a descriptive summary of services. There has not been a study in Portland using standard nomenclature and a congruent methodology to describe the cardiac arrest population and analyze the system response to this population.

CONCEPTUAL FRAMEWORK

A model of evaluation taken from general systems theory and based on structure, process, and outcome, (Wolff, 1986) can be used to examine primary cardiac arrest in Portland. In this model, structure refers to the characteristics about the environment or population that are important for effective execution of the process. Process is the intervention or response. Outcome in the structure-process-outcome model is the result of the process.

This study analyzes primary cardiac arrest in relation to structure, process, and outcome. Demographic characteristics of the cardiac arrest population such as gender, age, prior medical history, and the arrest circumstances such as time of day, location, witness present, and presenting rhythm comprise the structure. The process evaluation is an examination of the system response to the cardiac arrest population consisting of: the initiation of bystander CPR, the timely response of ALS, and the timely response of defibrillation when needed. Finally, outcome is evaluated by examining survival from cardiac arrest.

Feedback is information about the structure, process, and outcome, that can be used to monitor and evaluate the system and guide it to a more effective performance (Kast and Rosenzweig, 1981). Feedback can be both positive and negative and can lead to process changes, or structural changes, for the purpose of improving outcome. Employing the structure-process-outcome evaluation model, this study intended to gather important information about primary cardiac arrest in Portland.

RESEARCH QUESTION

The purpose of this study was to describe the primary cardiac arrest population in metropolitan Portland and to assess the EMS system response with respect to known factors associated with survival, specifically; bystander CPR, an ALS response within eight minutes, and defibrillation within ten minutes for a presenting rhythm of VF. The specific questions this study addressed were:

1. Is there a characteristic composition to the cardiac arrest population in Portland?
2. Is there a geographic and temporal pattern to cardiac arrest in Portland?
3. Is cardiac resuscitation care in Portland timely and effective?
4. Is there a geographic and temporal difference in the timeliness and effectiveness of cardiac resuscitation in Portland?

CHAPTER II

METHODS

This retrospective study evaluated data from the Oregon Health Sciences University (OHSU) cardiac arrest registry in order to characterize the cardiac arrest population and assess the EMS system response to this population.

Setting

Metropolitan Portland within Multnomah County was the setting for this study. Composed of 145 census tracts covering an area of approximately 200 square miles, and a population of 516,601 (Metro, 1990), the city of Portland and the majority of Multnomah County's population lies within this area. County lines border the north, south, and west perimeter of the area. The east boundary extends to 201st Avenue.

Metropolitan Portland's EMS system is two tiered. The Portland Bureau of Fire, Rescue, and Emergency Services (PFB) responds to all 911 calls requesting medical assistance, a volume of over 30,000 medical emergency calls annually. A BLS fire rescue unit is dispatched as a first response. If the nature of the 911 call is such that advanced life support may be required, an ALS fire rescue unit is dispatched simultaneously. At the time of this study, nineteen BLS and ten ALS fire units were geographically located to provide a BLS first response within four minutes and an ALS response within eight minutes 90% of the time. In an effort to streamline dual response on life threatening calls, PFB initiated an ALS first

response in target areas during the study period. For all ALS calls, an ALS ambulance unit from one of three private companies is dispatched to assist and transport individuals to medical facilities. At the time of the study, ALS ambulance units were geographically situated to provide an ALS response within eight to ten minutes 90% of the time.

Sample

The sample was composed of all individuals sustaining a primary cardiac arrest within the 145 census tracts of Multnomah County's Metropolitan Portland during the period of January 1, 1991 - December 31, 1991 for whom ALS personnel were dispatched and resuscitation attempted. All ages were included. Individuals who had a cardiac arrest secondary to an obvious noncardiac process such as sudden infant death syndrome, drug overdose, smoke inhalation, drowning, hanging, electrocution, gastrointestinal hemorrhage, or a traumatic injury were excluded from the study. Individuals sustaining a cardiac arrest after the arrival of EMS personnel were excluded from the study. Finally, cases of cardiac arrest occurring within the study area for whom a rescue vehicle arrived but resuscitation not initiated, were not entered into the study.

Data Collection Methods

The cardiac arrest registry is a data base for cardiac arrest cases occurring in Multnomah, Clackamus, and Washington counties. Prehospital care providers submit copies of their cardiac arrest care reports to the Division of Research Programs of the Department of Emergency Medicine at OHSU for entry into the

registry. Research assistants trained in reading the prehospital care form extract and enter data into the registry. Information taken from the prehospital care report forms reflect patient demographics, response times, and medical care rendered. Information regarding patient survival is entered at a later date by the research assistant, and obtained through call backs to receiving hospitals and the coroner's office.

Approval to access the cardiac arrest registry was obtained from the Director of Research Programs of the Department of Emergency Medicine. The Data Resource Center, a division of the Metropolitan Service District's Transportation Department, assisted in converting all incident and resident addresses in the data base to the corresponding census tract codes. Cases meeting the study criteria were then obtained from the registry for evaluation.

From each record, the following data were obtained: ID number, gender, age, date of arrest, location of the arrest, census tract where the cardiac arrest occurred, census tract where the victim resided, past medical history, witness, time of 911 dispatch call, time of ALS dispatch, arrival time of ALS unit, unit responding, bystander CPR, initial monitored cardiac rhythm identified by the paramedic, the time of the first defibrillatory shock, transport to the hospital, and survival from the hospital.

To assure strict confidentiality, no patient identifiers, including name or resident address were requested from the registry. Request for exemption from the

University Hospital Human Research Committee Review Board was submitted and approved.

Procedure

The study area was divided into seven geographical regions based on natural boundaries and were identified as follows: North Portland (N), Northeast Portland (NE), Southeast Portland (SE), Northwest Portland (NW), Southeast Portland (SE), East County (E), and Sauvie Island/Columbia Slough (S/C) (Appendix A). Based on the census tract in which the cardiac arrest occurred and the census tract in which the victim resided, the corresponding region for the incident site and the patient's residence were identified and entered in each record. An ALS call response interval was determined for each case and defined as the number of minutes elapsed from receipt of the call by the EMS dispatchers to the moment the ALS unit arrived at the site. A defibrillation interval was also determined from the difference in time from receipt of the call to the moment of defibrillation.

The entries for the variables witnessed arrest and bystander CPR were recoded as dichotomous variables. For witnessed arrest, the entry was recoded as true if there was a coding indicating a bystander witnessed the event. Missing responses and responses marked "no" were recoded as false. Bystander CPR was recoded the same way. If the entry indicated a bystander initiated CPR, it was recoded as true. If the entry indicated that an EMT initiated CPR, or if the entry

was blank, or had a question mark, or was marked "no", the entry was recoded as false.

Variables

The structural variables in this study were the following: gender, age, location of the arrest, region of the incident and region of the victim's residence, time of arrest, medical history, witnessed arrest, and the presenting rhythm identified by the paramedic. The process variables were: bystander CPR (CPR performed by someone who was not a part of the EMS response), ALS call-response interval, and defibrillation interval. The outcome, or dependent variable, was patient survival and was defined as discharged from the hospital alive.

Data Analysis

Data from the registry was imported into SPSS-PC version 4.0, a statistical software program. Chi square analysis was used to test the assumption of no difference between outcome groups for the discrete variables and for bivariate comparisons. To assess for a geographic pattern to cardiac arrest, the incidence of cardiac arrest was examined by region of incident site and region of residence. For cardiac arrest by region of residence, census data was used to calculate the observed incidence rate for the study area. Using census data and the observed incident rate, the expected rate was calculated for each region. A Summary Chi square based on a Poisson distribution (Cain and Dier, 1992) was calculated, and the sum was compared to a chi square table with six degrees of freedom. The same procedure was followed for cardiac arrest by region of incident site .

To determine if there was a temporal pattern to cardiac arrest, the day was stratified into the following six hour time periods: 0001-0600, 0601-1200, 1201-1800, 1801-2400. Single variable chi square analysis was used to test the hypothesis of no temporal difference.

The Student t Test was used to compare gender mean ages. A one-way analysis of variance was used to compare inter-regional mean ALS call-response intervals and defibrillation intervals.

For all statistical tests, a two tailed $p < .05$ was considered significant. All frequencies were rounded to the nearest percent.

CHAPTER III

RESULTS

A total of 343 individuals within the study area presented in primary cardiac arrest to EMS personnel for which resuscitation was attempted between January 1 and December 31, 1991. There were 20 additional cases in which the cardiac arrest occurred after arrival of EMS; these latter cases were not entered into the study.

I: "IS THERE A CHARACTERISTIC COMPOSITION TO THE CARDIAC ARREST POPULATION IN PORTLAND?"

The sample was composed of 222 (65%) males and 121 (35%) females. Their mean age was 67.15 $\pm$ 15.67 (SD) years (range, 21 to 99 years). The mean age for women was 70.66 years while the mean age for men was 65.23 years (Table 1). The difference was significant, $t(210) = 2.94$, $p = .004$).

Table 1

Cardiac Arrest by Age Group in Males

Age Group	Mean Age	Std. Dev.	Cases	No. Survived
20 - 44	36.4	5.54	19	1 (5%)
45 - 54	49.3	2.95	34	7 (21%)
55 - 64	60.3	2.55	41	6 (15%)
65 - 74	69.92	2.88	65	9 (14%)
75 and up	80.89	4.91	63	7 (11%)
Total	65.23	14.34	222	30 (14%)

Cardiac Arrest by Age Group in Females

Age Group	Mean Age	Std. Dev.	Cases	No. Survived
20 - 44	33.73	7.10	11	2 (18%)
45 - 54	50.36	2.91	11	0
55 - 64	58.50	3.32	14	1 (7%)
56 - 74	69.63	3.02	24	1 (4%)
75 and up	84.18	6.51	61	5 (8%)
Total	70.66	17.39	121	9 (7%)

Nearly all (88%) of the sample resided in the study area. The victim's resident address was unknown in only 12 (4%) cases. Most cardiac arrests occurred in the home (68%) and less frequently in a public building (8%), on a

street (7%), or in a residential institution (7%). Ten cardiac arrests (3%) occurred in a recreational location and three (1%) in an industrial location. The remaining 5% occurred in a variety of locations.

The medical history was known in 266 (78%) cases. Cardiac disease was the primary existing medical condition in 167 (49%) cases. In 68 (20%) cases, the primary medical condition listed was the following: pulmonary disease (n=24), stroke (n=8), diabetes (n=11), hypertension (n=11), cancer (n=4), seizure disorder (n=3). In 31 (9%) cases, the individual had no medical problems and the cardiac arrest was the first indication of heart disease. The medical history was unknown in 50 (15%) cases. Information regarding the medical history was missing in 17 (5%) cases.

The cardiac arrest was seen or heard by someone in 178 cases (52%). The highest percentage of witnessed arrests occurred in public buildings (88%, n=26) or on a street (60%, n=25). Fifty percent of the arrests in residential institutions (n=24) and recreation/sports areas (n=10) were witnessed. Less than half (47%, n=232) of the arrests in the home were witnessed.

Ventricular fibrillation was the presenting cardiac rhythm determined on arrival of the ALS personnel in 192 (56%) cases. There was one case of ventricular tachycardia. Of 150 cases presenting in rhythms other than VF/VT, 73 patients (49%) were found in asystole, 34 patients (23%) were in EMD, 18 patients (12%) were in an idioventricular rhythm, eight patients (2%) had an agonal rhythm, seven patients (5%) did not have a rhythm listed, five patients (3%) had

pulseless bradycardia, two (1%) were listed as having a normal sinus rhythm, and there was one case each of atrial fibrillation, complete heart block, and sinus tachycardia. Witnessed cases of cardiac arrest were more likely to have a presenting rhythm of VF/VT (61%) than nonwitnessed cases (39%).

II: "IS THERE A GEOGRAPHIC AND TEMPORAL PATTERN TO CARDIAC ARREST IN PORTLAND?"

A total of 302 patients resided in study area for a resident incidence rate of 5.8 cardiac arrests per 10,000 population. There was a statistically significant difference amongst the regions in the incidence of cardiac arrest compared to the population density, x^2 (6,n=302) = 13.2, p <.05 (Table II). Sauvie Island/ Columbia Slough had a significantly greater resident arrest rate while Southwest Portland had a significantly smaller resident arrest rate as compared to the other regions.

The overall incidence rate for 343 cardiac arrests occurring in the study area was 6.6 cases per 10,000 population. There was a significant difference in cardiac arrest incident site rate amongst the regions, x^2(6, N=343) = 12.63 p <.05 (Table 3). Sauvie Island/ Columbia Slough had a significantly higher incidence of cardiac arrest cases occurring in the area as compared to the other regions.

Table II

Cardiac Arrest by Resident Location in Portland For 1991

Region	Census	Cases	Expected Cases	Summary Chi square	x^2 Multiple Comparison
S/C	18,534	19	10.83	6.16	6.39*
NW	16,534	9	9.84	.07	0.05
SW	75,256	30	43.99	4.49	5.21*
SE	127,451	80	74.50	0.41	0.54
E	117,097	69	68.44	0.01	0.01
NE	90,043	46	52.63	0.86	1.01
N	71,388	49	41.73	1.27	0.22
Total	516,601	302+		x^2 = 13.3*	

incident rate = 5.845/10,000
+ 41 cases not analyzed in this table
* $p<.05$

Table III

Cardiac Arrest by Incident Site in Portland For 1991

Region	Census	Cases	Expected Cases	Summary Chi Square	x^2 Multiple Comparison
S/C	18,534	23	12.305	9.30	9.65*
NW	16,832	13	11.174	0.30	0.31
SW	75,256	40	49.962	1.99	2.39
SE	12,7451	88	84.615	0.14	0.18
E	117,097	70	77.741	0.77	1.0
NE	90,043	57	59.780	0.13	0.16
N	71,388	52	47.394	0.00	0.52
Total	516,601	343	343	x^2 = 12.63*	

incident rate = 6.64/10,000
* $p<.05$

The time of day was significant for cardiac arrest occurrences, $x^2(3, N=343) = 41.2$, $p < .001$. The highest frequency (35%) occurred between noon and 6PM while the lowest frequency (11%) of arrests occurred between midnight and 6AM (Table IV). There was not an inter-regional temporal difference to cardiac arrest.

Table IV

Cardiac Arrest by Time of Day

Time	Cases	Percent
0001-0600	36	11%
0601-1200	97	28%
1201-1800	115	34%
1801-2400	94	27%

III: "IS CARDIAC RESUSCITATION CARE IN PORTLAND TIMELY AND EFFECTIVE?"

The mean ALS call-response interval was 4.3 $\pm$ 1.2 (SD) minutes. The range was from less than a minute to fourteen minutes. ALS units reached the victim within seven minutes 95% of the time. The mean defibrillation interval for

an initial rhythm of VF was 7.07 $\pm$ 3.39 (SD) minutes. The range was from less than a minute to twenty-eight minutes.

Bystander CPR was initiated on 70 patients (20%). The frequency of bystander CPR was significantly greater among witnessed cases of cardiac arrest than among nonwitnessed cases (26% vs 14% respectively; p <.01) (Table V). Bystander CPR was most often initiated in public buildings (42%, n=26). CPR was initiated on only 31 patients (13%) who arrested at home. There was no difference in the frequency of bystander CPR based on victim gender.

Table V

Frequency of Bystander CPR in Witnessed and Nonwitnessed Cardiac Arrest

Witnessed	Bystander CPR	Cases
Yes	Yes	47 (27%)
Yes	No	131 (74%)
Total Witnessed		178 (100%)
No	Yes	23 (14%)
No	No	142 (86%)
Total Nonwitnessed		165 (100%)

Survival was determined for all but one of the 343 cases (Table VI). In all, 124 (36%) persons were pronounced dead at the scene; an additional 179 (52%) persons were transported to the hospital but subsequently died. One patient's outcome was unable to be verified after being transported to the hospital. There were 39 (11%) survivors. Nine (7%) women survived and 30 (14%) men survived. There was no difference in survival with respect to patient sex or age.

A witnessed cardiac arrest was associated with survival, $x^2(1) = 19.04$, $p < .001$. Survival in witnessed arrests was 19% (n=177) versus 4% (n=165) in nonwitnessed arrests (Table VII).

Survival was significantly greater for individuals who had bystander CPR compared to those who did not, $x^2(1) = 17.32$, $p < .001$. Twenty nine percent (n=70) of the patients who had bystander initiated CPR survived compared to 7% (n=272) of the patients who did not have bystander CPR (Table VIII).

Survival was significantly greater when the presenting rhythm was VF/VT versus other combined rhythms, $x^2(1, N=342) = 23.39$, $p < .001$. The survival rate in persons presenting in VF/VT was 19% (n=193). Of 39 survivors, 36 had an initial rhythm of VF/VT.

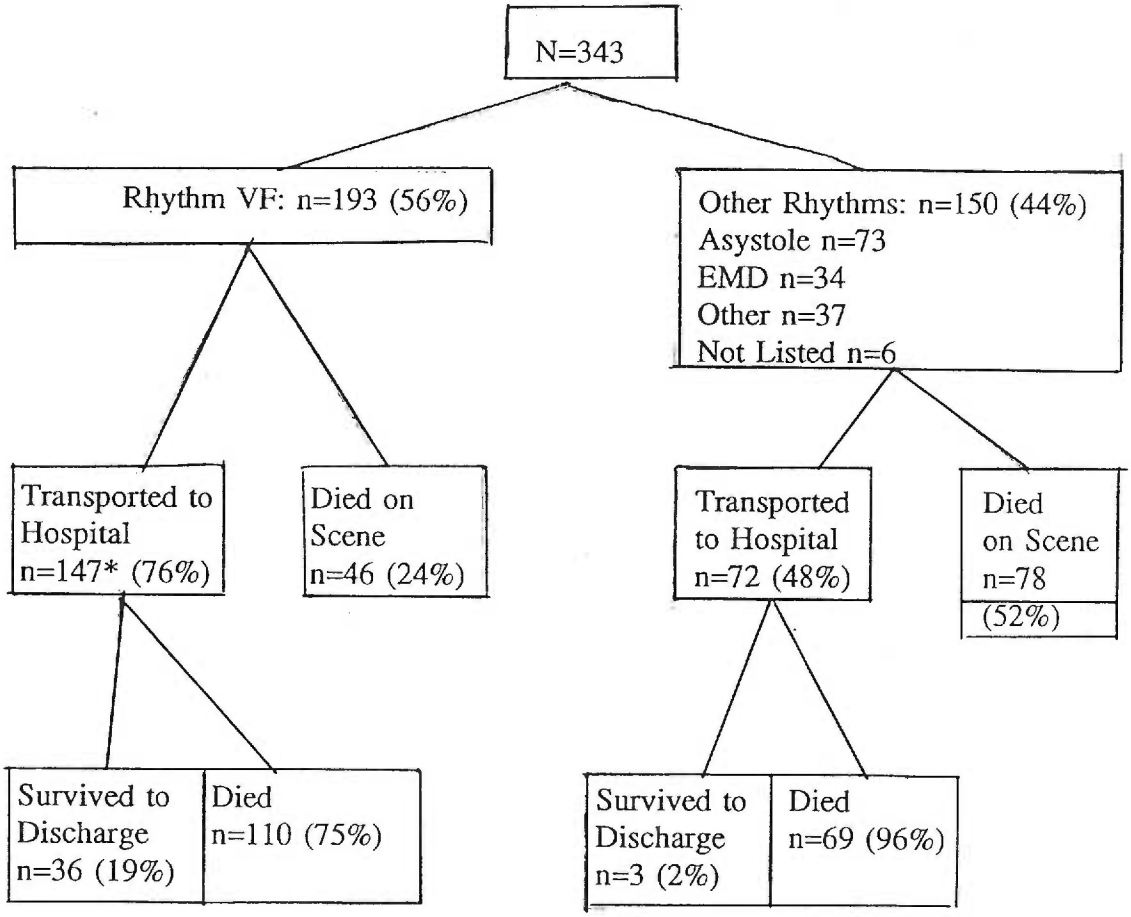
Survival was determined for 118 patients who had a witnessed arrest and an initial rhythm of VF/VT. Survival was 41% (n=39) when bystander CPR was initiated compared to 19% (n=79) without bystander CPR. This difference was significant, x^2 (1, n=118) =6.5, $p < .01$ (Table IX). Interestingly, when the ALS response interval was stratified in two minute increments up to seven minutes, chi

square analysis revealed no association between the ALS response interval and survival in witnessed VF. Eight patients (36%, n=22) survived when the ALS call-response was within two minutes. When the response interval was greater than seven minutes, three (38%, n=8) patients survived (Table X). This phenomenon held true for defibrillation interval as well. When the defibrillation interval was stratified into two minute increments up to nine minutes and compared to survival, there was not a significant difference in the survival rate (Table XI). In the two cases in which the defibrillation interval was within two minutes, neither patient survived. In 33 cases with a defibrillation interval greater than nine minutes, ten persons (30%) survived.

Table VI

Primary Cardiac Arrest Outcome

January 1 - December 31, 1991



* survival after transport unknown in one case

Table VII

Survival in Witnessed and Nonwitnessed Cardiac Arrest

Arrest	Cases	Survived
Witnessed	177	33 (19%)
Not witnessed	165	6 (4%)
Total	342	39 (11%)

Table VIII

Survival from Cardiac Arrest With and Without Bystander CPR

Arrest	Cases	Survived
Bystander CPR	70	20 (29%)
No Bystander CPR	272	19 (7%)
Total	342	39 (11%)

Table IX

Association Between Witnessed Event, Bystander CPR, and Survival in Cardiac Arrest Presenting in VF/VT

Witnessed Event	Bystander CPR	Cases	Cases Survived
Yes	Yes	39	16 (41%)
Yes	No	79	15 (19%)
No	Yes	10	3 (30%)
No	No	64	2 (3%)

Table X

ALS Call Response Interval and Survival Outcome for VF/VT

ALS Response Interval (minutes)	Total Cases	Cases Lived	Cases Witnessed	Cases Lived
1 - 2	32	9 (28%)	22 (69%)	8 (36%)
3 - 4	90	15 (17%)	55 (61%)	13 (24%)
5 - 6	57	8 (14%)	33 (58%)	7 (21%)
7 or more	13	4 (31%)	8 (62%)	3 (38%)
total	192	36 (19%)	118 (61%)	31 (26%)

Table XI

Defibrillation Interval and Survival in Witnessed VF/VT

Defibrillation Interval (minutes)	Cases	Number Survived
0 - 2	2	0
3 - 4	19	6 (32%)
5 - 6	33	11 (33%)
7 - 8	28	2 (7%)
9 and above	33	10 (30%)
Total	115	29 (25%)

IV: "IS THERE A GEOGRAPHIC AND TEMPORAL DIFFERENCE IN THE TIMELINESS AND EFFECTIVENESS OF CARDIAC RESUSCITATION IN PORTLAND?"

There was no difference amongst the regions in frequency of bystander CPR. There was a significant difference amongst the regions in the mean ALS call response interval, $F(6, 331)= 2.8$, $p < .01$). Sauvie Island/Columbia Slough with a mean ALS response time of 5.54 minutes was significantly longer than North Portland with a mean ALS response time 3.76 minutes (Table XI). This finding was confirmed with Scheffe's post hoc test ($p < .05$). There were no significant inter-regional differences in defibrillation intervals (Table XII).

In 17 (5%) cases, there was a prolonged ALS response interval of eight minutes or greater. Seven cases (41%) occurred in East county and four cases (24%) occurred in Sauvie Island/Columbia Slough. Eight cases (47%) occurred in the morning between 6AM and noon. In thirteen (76%) cases with a prolonged ALS response interval, the presenting cardiac rhythm was VF; of these, four (31%) survived.

Table XII

ALS Call Response Interval by Region (in minutes)

Region	Cases	Mean	Min	Max	Std. Dev.	95% Confidence Interval
E	70	4.49	1	14	2.35	3.93 To 5.05
N	51	3.76	<1	9	1.89	3.23 To 4.30
NE	56	4.38	1	10	1.71	3.92 To 4.83
NW	13	3.38	1	10	1.71	2.58 To 4.19
S/C	23	5.52	2	12	2.73	4.34 To 6.70
SE	87	4.12	1	8	1.63	3.85 To 4.54
SW	38	4.26	1	9	1.87	3.65 To 4.88
Total	338[+]	4.29	<1	14	1.98	4.07 To 4.50

[+] No ALS in times for 5 cases

One-way analysis of variance

Source	DF	sum of squares	mean squares	*F* ratio	*F* prob.
between groups	6	63.51	10.58	2.77	.01
within groups	331	1263.65	3.82		
total	337	1327.16			

Table XIII

Defibrillation Interval for VF by Region (in minutes)

Region	Cases	Mean	Min	Max	Std. Dev.	95% Confidence Interval
E	34	7.62	1	16	3.35	6.45 To 8.79
N	28	5.79	1	13	3.12	4.56 To 7.01
NE	31	7.65	3	22	3.74	6.27 To 9.02
NW	10	6.60	5	9	1.71	5.37 To 7.82
S/C	14	7.07	3	13	2.53	5.61 To 8.53
SE	55	6.85	3	28	3.78	5.83 To 7.88
SW	15	8.13	5	14	2.75	6.61 To 9.66
Total	187	7.07	1	28	3.39	6.58 To 7.56

One-way analysis of variance

Source	D.F.	Sum of Squares	Mean Squares	*F* Ratio	*F* Prob
Between Groups	6	88.36	14.73	1.29	.262
Within Groups	180	2047.74	11.38		
Total	186	2136.10			

CHAPTER IV

DISCUSSION

Using an evaluation process based on structure, process, and outcome, this study sought to describe the primary cardiac arrest population in Metropolitan Portland and assess the community's ability to deliver prompt and effective assistance to this population based on factors that have been associated with survival. The findings related to structure and process are discussed with respect to cardiac arrest outcome.

Structure

"Fate factors", the variables related to the individual or to chance occurrence over which there is little control, were used to describe the cardiac arrest population.

Gender and Age

The number of men in this study was nearly double the number of women which was consistent with the literature. To verify that this finding was not reflecting the gender composition in Portland, census information was obtained. The 1990 census data for ages 44 and above indicate that the area's gender composition is nearly nearly equal with 49% being male and 51% female.

Sixty-two percent of the arrests occurred in persons over the age of 64. Nearly 20% were over the age of 80. Fifty percent of the women were older than age 74 at the time of their arrest. Despite this large proportion of elderly patients,

age was not significantly associated with survival from cardiac arrest. This is in contrast to the Lucas/Kent County investigation (Ritter, 1985) with similar age group categories where survival was significantly higher in younger groups than older groups.

Medical History

Although the literature suggests a greater proportion of sudden deaths occur in persons without known cardiac disease, 70% (N=343) of the Portland group had known medical disabilities, and of these, 63% were cardiac. The relationship between existing medical conditions and survival from cardiac arrest have been inconclusive. In this study there were six (19%) survivors from the subset of patients without medical problems, and from the group of patients in which the medical history was unknown, ten (20%) survived. In those with known cardiac problems, 19 (11%) persons survived while only two (4%) survived from the group of patients who had a history of diabetes, hypertension, or pulmonary disease. Although the numbers were small, those without medical problems seemed to have a better outcome than those with known cardiac or associated conditions. Thus, if the majority of the cardiac arrest population in Portland has knowledge of a cardiac or comorbid condition, then it seems prudent that it is this population that should be targeted for cardiac arrest prevention strategies.

This study revealed that knowledge of a heart condition did not influence the frequency of bystander CPR. In the home, 19% (n=119) of those with a

known cardiac history had CPR performed by a bystander. For those without a known cardiac condition, 14% (n=113) had bystander CPR performed.

Location

Nearly all of the patients resided in the study area to support the notion that cardiac arrest in the community is primarily indigenous. In only 29 cases (8%) was the victim a nonresident of the study area. Sixty-eight percent of the cases occurred in a home, of which 94% were in the victim's own home. This finding is particularly important as an identified location where prevention education can be of value.

Sauvie Island/Columbia Slough, both as a region of incident site and as a region of residence, had a significantly greater number of cardiac arrests proportionate to its population compared to the other regions. Because this was a single strata analysis using the total population without adjustments for age and sex, the validity of the results could be questioned. In a parallel study, Feero (1993) performed a stratified analysis by adjusting each region's population for age and sex and then determined the relative risk for cardiac arrest. Sauvie Island/Columbia Slough had a significantly larger relative risk for primary cardiac arrest, both as a region of incident site and as a region of residence. Although Sauvie Island/Columbia Slough is the largest of the seven regions covering 80 square miles, it is also one of the least populated with 18,500 people. Over half the area is rural farmland. It is the only region with two populated islands, and the remainder of the region is a peninsula bordered by the Willamette and Columbia

River. Is the geography of Sauvie Island/Columbia Slough a factor contributing to the higher relative risk? Do the residents of this area have more cardiac risk factors than the residents of the other regions? More investigation is needed to determine if Sauvie Island/Columbia Slough's geography or the residents' lifestyle are contributing to the larger relative risk.

Time of day

Cardiac arrest occurrence followed a diurnal pattern. The number of arrests increased during the morning hours, peaked in the afternoon hours, and decreased during the evening hours. Few arrests occurred during sleep hours. This is in concurrence with previous investigations (Eisenberg et al, 1984).

Witnessed Arrest

More than half of the cardiac arrests in this investigation were witnessed corresponding with the literature. In this study, a witnessed arrest was associated with a rhythm of VF, bystander CPR, and survival. Of the 39 survivors, 33 were witnessed arrests. In the group of witnessed survivors, 31 were found in a rhythm of VF, and 16 had bystander CPR.

In contrast to the findings in Tucson (Spaite et al., 1990) and Arrowhead (Bachman et al., 1986) with no survivors from a nonwitnessed arrest, there were six survivors in the Portland group of nonwitnessed arrests. Five had bystander CPR initiated and were found in a rhythm of VF. In all cases, the ALS response was within seven minutes. Some investigators report only the outcome of witnessed arrests assuming that nearly all survivors are within this subgroup of

patients and refrain from examining the nonwitnessed cases (Eisenberg et al., 1990; Roth et al., 1984; Stueven et al., 1986;). While this may be practical for multiple system comparisons, examination should not be restricted to witnessed events only. As found in this study, outcome is influenced by factors at several points, and it is important to analyze the nonwitnessed group of survivors for those factors that contribute to improving survival in the absence of a witnessed arrest.

Rhythm

The majority of the Portland cardiac arrest population had a presenting rhythm of VF. This was not surprising as nearly all community studies have found similar findings. Consistent with the literature, survival was significantly higher in patients with a presenting rhythm of VF/VT. There were only three survivors whose initial rhythm was not VF. One survivor had an initial rhythm of sinus tachycardia, the second survivor's presenting rhythm was EMD, and the third survivor was found in asystole. Bystander CPR was initiated on the victim who had a rhythm of sinus tachycardia. In the other two cases, the cardiac arrest was witnessed. In all three cases, the ALS call response was within four minutes.

Process

Three system intervention variables were evaluated: the frequency of bystander CPR, an ALS call response interval within eight minutes, and a defibrillation interval within ten minutes for VF.

Bystander CPR

The Tucson study (Spaite, 1990) revealed that even in cities with rapid ALS mean response times (five minutes), bystander CPR was associated with improved survival from cardiac arrest. The results of this study corroborate with the results in Tucson. In Portland, the mean ALS response was four minutes. When patients with an initial rhythm of VF were examined, survival was significantly higher in the group that had bystander CPR initiated compared to the group without bystander CPR (29% versus 7% respectively). This difference was even more dramatic when the event was witnessed (41% versus 19% respectively).

Although bystander CPR was found to be associated with survival, bystander CPR occurred in only 70 (20%) cases. Even when the event was witnessed (n=178), bystander CPR occurred only 26% of the time. This is particularly low compared to our neighboring Seattle and King County which report bystander CPR rates of 36-54% (Eisenberg et al, 1990) or in larger cities such as Chicago with a reported 28% rate of bystander CPR (Becker, 1991).

Few investigators have examined the frequency of CPR in the home. This investigation found the frequency rates sobering. Only 31 (13%) of the 232 patients who arrested in the home had bystander CPR performed prior to EMS arrival even though 47% of the arrests were witnessed by someone. Of 110 witnessed events, CPR was initiated in only nineteen (17%) cases. A total of nineteen persons who arrested at home survived. Survival was significantly higher in those patients that had bystander CPR than in the group that had no CPR (19%

versus 6% respectively, $p < .027$ by Fisher's exact test). Within the group of witnessed arrests, survival was still higher in the bystander group although the numbers were too low for statistical significance (Table XV). These results seem to indicate that the place to focus our efforts in CPR training is in the home to the companions of those with known cardiac disease or at high risk for cardiac disease.

Table XV

Cardiac Arrest in the Home: Association Between Witnessed VF, Bystander CPR, and Survival

Bystander CPR	Witnessed Event	Cases	Cases Survived
Yes	Yes	19	3 (16%)
No	Yes	91	11 (12%)
Yes	No	12	3 (25%)
No	No	110	2 (2%)

ALS Call Response Interval And Defibrillation Interval

Most studies examine only ALS response time with the assumption that defibrillation for VF is within a very short time frame. This investigation reviewed not only the ALS call response interval but the interval to the first defibrillatory shock for rhythms presenting in VF. The data revealed a mean elapsed time of only four minutes from the EMS dispatch call to the arrival of the

ALS unit and seven minutes from the EMS dispatch call to the first defibrillatory shock. This response interval is shorter than the mean ALS response intervals reported for other two tiered EMS midsized cities (Spaite et al., 1990; Stueven et al., 1986; Weaver et al., 1986) and certainly faster than the eight minute standard to which it was evaluated against.

In Chicago, Becker and co-workers (1991) were one of the first investigators to examine both intervals and found a mean of 16 minutes from collapse to defibrillation with a mean interval of eight minutes from ALS arrival to defibrillation, concluding this delay contributed to the low survival rate. In Portland, the mean interval after ALS arrival to defibrillation was three minutes, much shorter than in Chicago. To make valid inter-system comparisons however, comparable sized cities are needed.

The group of 118 witnessed cases presenting in VF was used to examine the effect of the ALS call response interval and defibrillation interval on survival. Previous investigators (Eisenberg et al., 1984; Ritter et al., 1985; Weaver et al. 1986) have reported a significant decrease in survival as the time to ALS and defibrillation increases. In this study, the ALS call response interval and defibrillation interval were stratified into two minute increments, and in neither situation was there a significant difference in survival amongst the groups. When ALS arrived within two minutes, eight of 22 patients (36%) survived. When the ALS interval was seven minutes or greater, three of the eight (37%) patients survived. Six of 21 patients (29%) survived when the defibrillation occurred

within four minutes of the dispatch call. Even when defibrillation occurred nine minutes or more after the dispatch call, 10 of 33 (30%) patients survived. Caution is exercised in reporting the significance of these results. This analysis examined the interval from the dispatch call to ALS arrival rather than from the moment the patient collapsed. To what extent the interval from time of collapse to time of 911 call and even later EMS dispatch call time altered the effect of response and defibrillation intervals with survival is unknown. Another important variable that was not addressed in this study was the role of the first responder. The BLS call response interval was unknown may have altered the influence of bystander CPR. Lastly, the results may have been a reflection of the small sample size in this subset of patients. A more sophisticated analysis is needed to determine the true significance of these results.

None of the survivors had an ALS response interval greater than seven minutes. Of the six patients with a defibrillation interval greater than fifteen minutes, none survived. In the group of survivors, the maximum interval to defibrillation and survival was thirteen minutes.

Amongst the regions, Sauvie Island/ Columbia Slough with ALS response intervals ranging from two to twelve minutes and a mean of five and a half minutes had a longer mean ALS call response interval. However, close examination of this region revealed only four of the 23 cases had an ALS response greater than seven minutes. The number of cases were too few to determine if this was of any clinical significance.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study documents the epidemiology of primary cardiac arrest in a mid-sized metropolitan area. The purpose of this investigation was to describe the population of primary cardiac arrest victims managed by the PFB and to report the results of early intervention; specifically bystander CPR, the ALS call response interval, and defibrillation interval for patients presenting in a rhythm of ventricular fibrillation. A retrospective analysis of primary cardiac arrest cases for 1991 was undertaken using data gathered from the Oregon Health Sciences University cardiac arrest registry. All patients who sustained a primary cardiac arrest within the study area for whom rescue personnel arrived and attempted resuscitation were entered into the study. The study area, comprising the city of Portland and surrounding area within Multnomah County, was divided into seven geographic regions based upon natural boundaries. Data gathered from the registry included: gender, age, time of arrest, location of the arrest, location of the victim's residence, description of the arrest site, witnessed event, presenting rhythm, bystander CPR, ALS response interval, defibrillation interval, and survival outcome. Between January 1 - December 31, 1991, 343 cases met the criteria and were evaluated.

Cardiac arrest occurrence followed a diurnal pattern with most arrests occurring in the afternoon. Sixty-eight percent of the arrests occurred in the home. Nearly twice as many men arrested as women. The mean age of the men was 65; women were on the average five years older. Eighty-eight percent of the subjects were residents of the study area. Sauvie Island/Columbia Slough was noted to have a proportionately higher rate of incident and resident cardiac arrests which was statistically significant. A history of cardiac disease or comorbid condition was known in 70% of the sample at the time of arrest. The cardiac arrest was witnessed by someone in 53% of the cases and ventricular fibrillation was the initial cardiac rhythm in 56% of the cases.

The early EMS system interventions of bystander CPR, ALS response interval and defibrillation interval were examined. Bystander CPR occurred in only 70 (20%) cases. Within the home, it occurred in only 31 (13%) cases. The mean ALS response interval for the study area was four minutes and 95% of the time the response was within seven minutes. There was a statistical significant difference in the mean response intervals amongst the regions. Sauvie Island/Columbia Slough was identified as a region with a statistically longer mean response interval of five and a half minutes compared to North Portland with a shorter mean response interval of three minutes and forty five seconds. The effect of response interval on survival could not be determined due to small sample size. The mean defibrillation interval was seven minutes; three minutes after ALS

arrival. No differences were found amongst the regions with respect to the defibrillation interval.

A total of 39 individuals were discharged alive from the hospital for a survival rate of 11%. Chi square analysis revealed a significant increase in survival for the following factors: initial rhythm of VF compared to other rhythms (19% versus 2%; p =.00001), witnessed event compared to nonwitnessed event (19% versus 4%; p =.00001, and bystander CPR compared to nonbystander CPR (29% versus 7%; p =.00001). Survival from witnessed VF was 26%. The subset of patients most likely to survive comprised those who had a witnessed arrest, had bystander CPR initiated, and had an initial rhythm of VF (41% survived). When the ALS response interval and the defibrillation interval were stratified into two minute increments to a total of eight and ten minutes respectively, no differences in survival were noted for either group of witnessed or nonwitnessed patients found in VF.

Limitations of the Study and Recommendations for Further Study

There were several limitations associated with this study. Information related to the first responder (BLS) was not retrievable. For 80% of the cases, the interval to CPR by BLS personnel was unknown, although it most likely occurred earlier than the ALS interval. To what extent the BLS first response confounded the results is unknown.

Data in the data base relied on prehospital care report forms and the veracity of the reports. The interpretation of definitions by the scribe, non

synchronized time clocks, and sometimes incomplete or selective information on the run report restricts the assessment of system performance. Bystander CPR and whether the event was witnessed were not always known to the paramedic filling out the form. For this investigation, all documented cases of bystander CPR or witnessed events were coded as true. All definite documentation of nonwitness or nonbystander CPR, as well as blanks or questions marks, were coded as false.

This study only looked at a single outcome - discharge from the hospital alive. Several investigators use two survival outcomes; admission to the hospital and discharge from the hospital. Admission to the hospital is equated with a successful resuscitation. In the definition of admission to the hospital, the patient must be alive for at least six hours. This outcome could not be ascertained in this investigation and hence only survival to hospital discharge was used. Undoubtedly some in-hospital factors influenced the outcome of survival to discharge. Further, we have no information on the neurologic status of the patient who survived.

Finally, the greater Portland metropolitan area lies within three counties. This investigation looked only at one county encompassing the city limits and a portion of the county. Caution must be made when generalizing these results to the entire Portland metropolitan area, especially with reference to the EMS response intervals as EMS care providers differ in the other two counties.

This study serves as a reference point for future research. Knowing where to target our prevention efforts, future research is needed on the effectiveness of programs developed. This was the first use of the cardiac arrest registry and

limitations were noted. Refinement of the data base will enable opportunities to address those limitations, and enable focused investigations on selected aspects of primary cardiac arrest.

One region was identified as having a statistically significant greater number of cardiac arrests proportional to its population. Because the numbers are small, future investigation is needed to determine if this is clinically significant. If it is significant, then future research is needed to investigate factors that are contributing to this higher incidence.

Implications for Nursing Practice

Prevention of cardiac disease is the ultimate goal in preventing cardiac arrest. Nurses in all areas of practice have opportunities when interacting with their patients to address prevention strategies such as control of hypertension, smoking, and lifestyle changes. On a political front, the nursing profession needs to be at the forefront in promoting public and legislative action to combat the identified risks for cardiovascular disease.

Improving survival from out of hospital cardiac arrest will in part depend on improving patient education and increasing citizen CPR training. There is an obvious need to reach patients with cardiac symptoms early in the course of their acute episode. Nurses have a role in educating the public regarding the recognition of signs and symptoms of ischemic heart disease, when and how to access EMS system, and how to perform CPR in the event of a cardiac arrest. The nurse clinician, the emergency department nurse, and the public health nurse represent

only a few of the nursing specialties most likely to come in contact with the population needing this information.

Within the Portland community, bystander CPR occurs only about 20% of the time, and in the home this drops to 13%. This study revealed the population that needs to be targeted for CPR training include middle age persons and older, persons with identified cardiac disease or comorbid conditions, and the partners of these persons. Nurses must play a role in identifying persons at risk, assessing their potential "cardiac arrest preparedness" and teaching cardiac arrest strategies when necessary. Essential components are identification of warning signs, rapid calling of 911 and CPR instruction. For individuals who live alone, nurses can help strategize a plan to reduce the chance of a nonwitnessed event. For nurses who are BLS instructor certified, there is an ongoing need for community CPR courses targeted for the older population.

Primary cardiac arrest is a multi-disciplinary problem. Collaboration in the research from several disciplines leads to more effective community program planning. This study reflected the collaborative efforts of individuals from medicine, nursing, and the EMS community. The analysis of primary cardiac arrest in the Portland area belongs to the community and the several disciplines that collectively are working to solve this public health problem.

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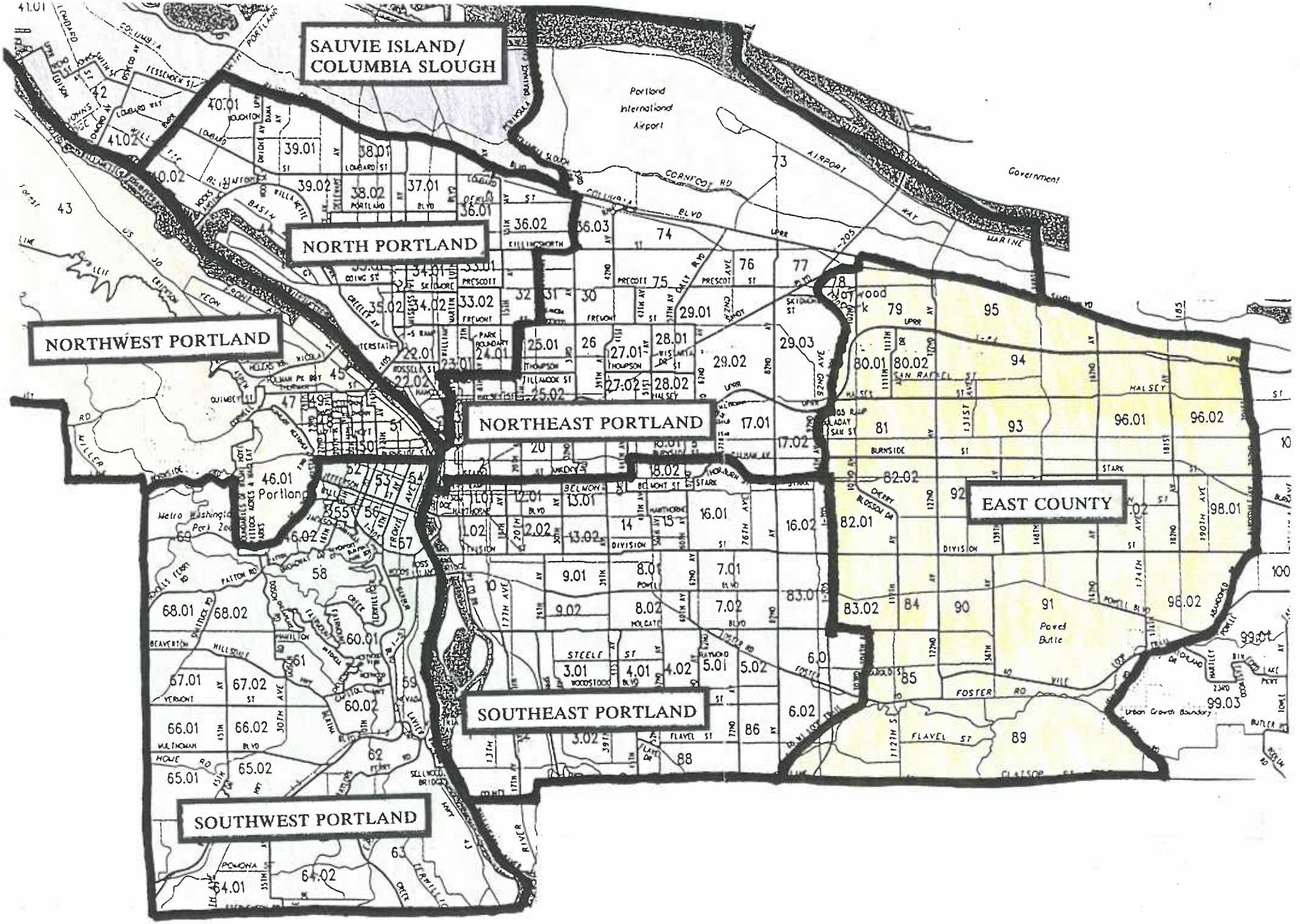
Appendices

Appendix A

Study Area Regional Map


SAUVIE ISLAND/
COLUMBIA SLOUGH
NORTH PORTLAND
NORTHWEST PORTLAND
NORTHEAST PORTLAND
EAST COUNTY
SOUTHEAST PORTLAND
SOUTHWEST PORTLAND
Portland International Airport
Government
Urban Growth Boundary

Appendix B

Demographics of the Survivors

CHARACTERISTICS OF THE SURVIVORS

ID No.	SEX	AGE	RESIDENCE	WITNESS	BYST. CPR	RHYTHM	ALS INTERVAL	DEFIB INTERVAL
1	M	79	SE	F	T	VF	7	7
2	F	55	N	T	F	VF	4	4
3	M	46	OUT	T	T	VF	4	7
4	M	64	OUT	T	T	VF	4	5
5	M	55	E	T	T	VF	4	6
6	M	47	SW	T	T	VF	2	4
7	F	72	NE	T	F	VF	1	
8	M	80	NE	F	F	VF	4	6
9	M	70	E	T	F	VF	6	9
10	M	64	SE	T	F	VF	6	4
11	M	55	N	F	F	VF	2	5
12	F	76	E	T	F	ASYSTOLE	3	
13	M	65	OUT	T	T	VF	7	13
14	M	50	SE	F	T	VF	4	10
15	M	69	E	T	F	VF	4	4
16	M	82	SE	T	F	VF	2	5
17	M	77	N	T	F	EMD	1	
18	F	32	OUT	T	F	VF	5	6
19	M	73	SE	T	T	VF	4	5
20	M	74	SE	T	T	VF	4	10
21	M	50	OUT	T	F	VF	2	5
22	M	79	SE	T	F	VF	7	11
23	M	69	SE	T	F	VF	2	6
24	M	72	E	T	T	VF	2	3
25	M	60	NE	T	F	VF	6	9
26	M	70	NE	T	F	VF	3	5
27	F	77	SE	T	T	VF	2	8
28	M	49	NE	T	T	VF	6	
29	M	48	S\C	F	T	VF	5	7
30	M	46	SE	T	F	VF	4	5
31	M	78	E	T	T	VF	1	9
32	M	44	N	T	T	VF	3	6
33	F	77	NW	T	T	VF	3	9
34	F	76	E	F	T	ST	4	
35	M	70	E	T	F	VF	3	4
36	F	22	SW	T	F	VF	3	10
37	M	82	NE	T	T	VF	5	5
38	F	79	OUT	T	T	VF	6	9
39	M	57	OUT	T	T	VF	2	5

AN ABSTRACT OF THE THESIS OF

PENNY STEVENS

FOR THE MASTER OF SCIENCE

Date receiving this degree: June 11, 1993

Title: ANALYSIS OF PRIMARY CARDIAC ARREST IN A METROPOLITAN AREA

Approved: Donna B. Jensen

Donna B. Jensen, R.N., Ph.D., Thesis Advisor

Primary cardiac arrest is a significant public health problem with a high incidence and mortality. Factors associated with survival from primary cardiac arrest include: a witnessed event, a cardiac rhythm of VF, a rapid EMS response, and early defibrillation. The purpose of this study was to describe the primary cardiac arrest population and assess the EMS response in a metropolitan area, and to identify risk groups that should be targeted for cardiac arrest prevention education.

A retrospective analysis was performed using data gathered from the OHSU Cardiac Arrest Registry on 343 individuals who sustained a primary cardiac arrest during 1991 for whom rescue personnel arrived and attempted resuscitation. The study area comprised the city of Portland and surrounding

area within Multnomah County and was divided into seven geographical areas based upon natural boundaries.

Men predominated the cardiac arrest population with their mean age being in the mid sixties. There was a known history of cardiac disease or a comorbid condition in the majority of the sample. Sixty eight percent of the arrests occurred in the home, 52% of the arrests were witnessed, 56% were found in VF, and 20% had bystander CPR performed. ALS had a mean response interval of 4.3 minutes and a mean defibrillation interval of 7.3 minutes. One region had a proportionately higher rate of incident and resident cardiac arrest cases.

Survival from cardiac arrest was 11% and in witnessed VF it was 26%. A significant increase in survival was demonstrated for the following factors: initial rhythm of VF, witnessed event, and bystander CPR. The highest survival rate occurred in the group of individuals who had a witnessed event, were found in VF. and had bystander CPR initiated.

Cardiac resuscitation care in Portland is timely and effective. Education strategies need to be directed toward middle aged persons with known cardiac histories and their significant others.