Spatial Cluster Analysis of Out-of-Hospital Cardiac Arrest in Mesa, Arizona

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

Premature death and disability from sudden cardiac arrest continues to be a serious public health burden. Cardiac arrest surveillance has sought to understand socio-demographic risk factors and geographic disparities of out-of-hospital cardiac arrest (OHCA) among cities, but little is known about such disparities at the neighborhood level. Understanding neighborhood-level risks is invaluable in guiding resource allocation, service provision, and policy decisions to improve public health and safety outcomes in a community. Mesa is developing an evidence-based strategy to promote cardiac health and improve survival from OHCA. The problem is the Mesa Fire and Medical Department (MFMD) has not analyzed its medical records data to identify at-risk populations or areas within the city with a high-incidence of OHCA. The purpose of this applied research project is to investigate the spatial patterns of OHCA incidence in Mesa to identify neighborhoods and public occupancies with the highest risk. Descriptive research methods were employed to answer the following questions: (a) what is the morbidity and mortality of OHCA in Mesa, Arizona, (b) are there particular characteristics of a population that place neighborhoods at greater risk for OHCA incidents, (c) which neighborhoods in Mesa demonstrate a high incidence of OHCA but low rates of bystander CPR, and (d) are there public locations in Mesa with persistently high annual incidence of cardiac arrests per site that might benefit from a public access defibrillator program? Clusters of OHCA events were found in neighborhoods with socially isolated older persons, as well as low-income minority populations. Hemodialysis centers, residential board and care facilities, and nursing homes had the highest annual incidence per site. Recommendations were made for health program components aimed at at-risk populations and high-incidence areas.
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Introduction

Out-of-hospital cardiac arrest (OHCA) remains a major cause of premature death and a significant public health problem (Bobrow, Vadeboncoeur, Clark & Chikani, 2008). The Mesa Fire and Medical Department (MFMD) continues to evaluate methods to improve patient care and provide the highest level of service possible. Toward this end, the MFMD has applied a multipronged approach to improve the rate of survival of OHCA (Looby, 2012). The Fire and Life Safety Division provides cardiopulmonary resuscitation (CPR) training at community events, corporate retreats, and local elementary and high schools; first responders now follow minimally-interrupted cardiac resuscitation (MICR) protocols to increase the effectiveness of defibrillation; paramedics induce post-resuscitation therapeutic hypothermia to improve survival and neurologic outcomes; and the Mesa Regional Dispatch Center has begun providing dispatcher-assisted instructions to encourage callers to initiate hands-only CPR prior to arrival of emergency medical services (EMS).

Despite advances in emergency medical systems and resuscitation science, the chance of survival from OHCA has remained relatively unchanged for nearly 30 years, nationally (Sasson et al., 2010). Unfortunately, few cities publish their OHCA survival statistics using the Utstein criteria reporting method. In cities that do, there are wide regional variations in OHCA incidence and outcomes (Nichol et al., 2008). However, little is known about variations in morbidity between neighborhoods within particular cities. Some studies have explored the differences between OHCA in residential versus
public locations with implications for public access defibrillation programs, but few have attempted to identify areas with a high incidence of cardiac arrests and low rates of bystander CPR. This is particularly concerning since bystander CPR is a “crucial yet weak link in the chain of survival for out-of-hospital cardiac arrest” (Vailancourt, Stiell, & Wells, 2008, p. 51), and “boosting CPR rates in the United States from the current average of 27% to 56% could save an additional 1500 lives per year (Sasson et al., 2010, p. 19).

Many communities have sought to improve survival rates by providing the lay rescuer with the tools and techniques needed to intervene in an OHCA event. Efforts have typically focused on bystander CPR training, public access defibrillation programs, or a combination of these approaches. When it comes to developing community-based interventions to improve public health and safety, “local data must drive local solutions” (Nichol et al., 1998, para. 11). Recent improvements to the City of Mesa’s geographic information systems (GIS) analytical tools, and the fire department’s conversion to electronic patient care records (ePCR) which follows the Utstein criteria, offer an opportunity to better understand the epidemiology and small area variations of OHCA in Mesa. The problem is the MFMD has not analyzed its medical records data to identify at-risk populations or areas within the city with a high-incidence of OHCA.

The purpose of this applied research project is to investigate the spatial patterns of OHCA incidence in Mesa to identify neighborhoods and public occupancies with the highest risk. Understanding the antecedent socio-demographic risk factors and geographic disparities of OHCA are invaluable in guiding resource allocation, service
provision, and policy decisions to develop an evidence-based strategy to improve public health education, CPR training delivery, automated external defibrillator (AED) placement, and ultimately improve survival. This project was completed as part of the National Fire Academy Executive Fire Officer Program course R274: Executive Analysis of Community Risk Reduction. Descriptive research methods were employed to answer the following questions: (a) what is the morbidity and mortality of out-of-hospital sudden cardiac arrest in Mesa, Arizona, (b) are there particular characteristics of a population that place neighborhoods at greater risk for out-of-hospital cardiac arrest incidents, (c) which neighborhoods in Mesa demonstrate a high incidence of out-of-hospital cardiac arrest but low rates of bystander CPR, and (d) are there public locations in Mesa with persistently high annual incidence of cardiac arrests per site that might benefit from a public access defibrillator program?

**Background and Significance**

“Cardiovascular disease is the leading cause of death both nationally, and in Arizona” (Han, Merrit, & Olmstead, 2005, p. 5). Despite progress in education and prevention initiatives and improvements in treatment options, cardiovascular disease (CVD) remains a leading cause of sudden cardiac death; in fact, “sudden cardiac death now accounts for more than half of all coronary heart disease deaths in the United States” (Saxon, 2005, p. S12). According to the latest data available from the Arizona Department of Health Services (ADHS), Arizona ranks 42nd in the U.S. in deaths due to heart disease (Olmstead & Weiler, 2005). Health status information for Arizona cities and towns indicates Mesa is well above state and county population-based rates for major cardiovascular diseases with 226.6 per 100,000 compared to 199.2 for the state and 175.4
for Maricopa County, and 124.5 per 100,000 for ischemic heart disease compared to 111.8 in the state and 102.7 in the county (Prestanski, Nohre, & Schumacher, 2010). Unfortunately, the first sign of CVD is often SCA, which account for an estimated 300,000 American deaths annually (McNally et al., 2011; Lloyd-Jones et al., 2011).

Many of the same risk factors associated with CVD also increase the risk of SCA. Among the non-modifiable risk factors is age (Mayo Clinic staff, 2010). Because the prevalence of ischemic cardiac disease increases with age, the incidence of sudden cardiac death increases with age in both men and women (Zipes & Wellens, 1998). 2010 Census data reports the median age for the Arizona population is 35.9 years, and 13.8 percent of the population is over the age of 65. Likewise, Mesa is becoming a more mature city. In 2000, the median age was 32 years; a decade later it is 34.6 (Nelson, 2011). The percentage of Mesa residents over age 65 is now 14.1, and those over 85 years old now make up over two percent of the city's population. Mesa is home to a number of large age-restricted "active adult" sub-divisions and planned communities, including Sunland Village, Sunland Springs Village, Sunland Village East, and Fountain of the Sun. While deed restrictions and private covenants vary on the minimum age, they typically require at least one person in a household be 55 years of age or older (Guntermann & Moon, 2002). Many of these communities have sprung up in the fast-growing area of southeast Mesa where EMS response times currently meet the 4-minute NFPA standard only about 50-percent of the time (Gonzalez, 2011).

According to the American Heart Association (2010) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiac Care, optimizing a patient’s potential for surviving an OHCA depends upon rapid completion of a sequence of actions...
in a “chain of survival:” (1) recognition of early warning signs, (2) activation of 9-1-1 and
the EMS system, (3) high-quality CPR performed by both bystanders and emergency
responders, (4) early defibrillation, (5) intubation and airway management, and (6) post-
resuscitative care and intravenous administration of medications. Efforts to improve the
management of sudden cardiac arrest have often focused on developing more advanced
cardiac life support (ACLS) medical interventions. Indeed, some have proven effective.
For example, clinical trails on therapeutic hypothermia have demonstrated improvements
to the quality-of-life of post-resuscitation patients (Bernard et al., 2002; The Hypothermia
After Cardiac Arrest Study Group, 2002).

But, despite some successes with the ACLS paradigm, the AHA (2010) still
recognizes that the most effective interventions are high-quality CPR and early access to
defibrillation. Studies continue to demonstrate regional variations in survival rates, with
communities with greater levels of bystander CPR and AED availability experiencing
survival rates as high as 49% (Nichol et al., 2008). The Ontario Pre-hospital Advanced
Life Support (OPALS) study tested the incremental effect of adding advanced life
support to a program of rapid defibrillation. The results indicated that, for cardiac arrest,
initial CPR and rapid defibrillation were more highly correlated to survival than ACLS
arriving within 8 minutes (Stiell et al., 2004). This article, among others, lends support to
the concept that the greatest gains for improving OHCA survival rates remains in
increasing bystander CPR and wider public access to defibrillators.

In a statewide effort to improve OHCA survival outcomes, the ADHS Bureau of
Emergency Medical and Trauma Service, in conjunction with the University of Arizona
Sarver Heart Center, has established the Save Hearts in Arizona Registry and Education
(SHARE) program (Bobrow et al., 2008). The purpose of this registry is to improve survival from OHCA by determining optimum treatment based on the location of the cardiac arrest incident. In this way, SHARE is focused on community-specific solutions. SHARE utilizes a database system that tracks the incidence of OHCA and analyzes the frequency and quality of bystander CPR, as well as how and where AEDs are being used. Public education is also a key component of SHARE. Results presented at the AHA 2009 Resuscitation Science Symposium showed that “overall incidence of bystander CPR rose from 25% to 40% after the program, while the overall incidence of hands-only CPR rose from 16% to 77%” (Brunk, 2010, ¶ 13). A shortcoming of the SHARE program is that it is intended mainly for hospitals, whereas neighborhood-focused studies could provide more detailed and actionable information to the MFMD.

This applied research project is significant to the MFMD in that it coincides with a concerted effort to expand the department’s activities to better suit customer expectations. The department has become an integral part of the overall health care system. Evolving market forces, expanding needs and community expectations are constantly impacting the department’s underlying mission. Pre-hospital health care now constitutes 80-percent of department emergency responses. To better reflect this reality, the department recently changed its name from the Mesa Fire Department to the Mesa Fire and Medical Department. With this new identity, it is important that the MFMD embrace its health care and public health roles by identifying measures that improve the health, wellness, and overall well-being of the community. The literature review will document the wealth of evidence that bystander CPR and early access to defibrillation improves community OHCA survival rates and the quality-of-life of survivors. The data
analysis will also provide an evidence-basis for the adoption of a Mesa Project Heart Beat program currently under consideration by the Mesa City Council public safety sub-committee. Project Heart Beat is envisioned as a public-private partnership to improve survival from sudden cardiac arrest (SCA) through a combination of preventative health education and outreach services, CPR training, and public-access defibrillation (PAD).

This project is related to the National Fire Academy’s (NFA) Executive Analysis of Community Risk Reduction (EACRR) course, which recognizes that risk reduction interventions must be tailored to suit the community so that they work effectively for local population groups. The foundation for this community-specific approach is research. As stated in the pre-course material:

Prevention initiatives should not take the form of a “canned” program, meant to be everything to everybody. Rather, each community must develop a specific plan to address the unique . . . problems of that community through a combination of combined preventive interventions. This is what community risk reduction is all about – a community assessing its unique . . . risks and hazards, and then developing and implementing specific intervention strategies to address those risks and hazards. (U.S. Fire Administration, 2011, p. 4)

Indeed, in the case of public access defibrillation programs, for example, the academic literature is replete with studies of the clinical effectiveness of AED deployment in various settings such as airports (Becker et al., 1998), casinos (Valenzuela et al., 2000), and fitness centers and golf courses (Reed et al., 2006). But, just because a particular facility has a high yield of OHCA in Kansas City (Gratton, Lindholm, & Campbell,
1999) or Copenhagen (Folke et al., 2009), does not necessarily mean the same facility in Mesa, Arizona will have a similar incidence.

Finally, this research project addresses two U.S. Fire Administration's (2010) strategic plan goals. The first is to "reduce risk at the local level through prevention and mitigation" (p. 13), the objective of which is to "[e]ncourage State, local, and tribal adoption of risk reduction, prevention, mitigation, and safety strategies" (p. 18). The project also uses the USFA strategic initiative of the National Fire Incident Reporting System (NFIRS) and applies it to identify public use occupancies with high-incidence of OHCA. Toward these goals, the project uses "modern data and information analysis" (p.19) to compile and analyze health status information in Mesa in order to address morbidity and mortality of sudden cardiac arrest at the neighborhood level. If high-risk neighborhoods and public occupancies can be identified, they may benefit from a program of targeted health prevention programs, CPR training, and AED placement.

**Literature Review**

A literature review was conducted as part of this applied research project to accumulate background information on the epidemiology of SCA. Using PubMed and the Arizona State University Library “One Search” Web portal, medical literature was searched using key works *sudden cardiac arrest, cardiovascular disease, cardiopulmonary resuscitation, automated external defibrillator, and emergency medical services*. Additional sources of information included academic journals, as well as professional and trade magazines, books, government and non-governmental organization (NGO) publications, position papers, newspaper articles, and Internet sites. This review
provided valuable insight into key issues and concepts especially as they related to socio-demographic determinants of sudden cardiac arrest, geographic patters of OHCA, and community-level programs to promote cardiovascular health and prevent sudden cardiac death.

**Socio-Demographic Determinants of Sudden Cardiac Arrest**

**Demographic factors.** SCA continues to be a serious public health issue in the United States. According to statistics compiled by the American Heart Association (AHA), sudden cardiac death accounts for over 300,000 American deaths annually, and fewer than 8% of persons who experience an OHCA survive (Lloyd-Jones et al., 2011). “Classic epidemiology has provided a great deal of useful information regarding the risk of life-threatening ventricular arrhythmias . . . and possible approaches to their prevention” (Myerburg, Interian, Mitrani, Kessler, & Castellanos, 1999, p. 18F). A particular challenge in addressing SCA through a community-specific prevention program, however, is the difficulty of predicting locations where OHCA events are likely to occur and calculating the relative risk of specific occupancies.

Researchers have found that the majority of SCA events have a cardiac etiology (Engdahl, Holmberg, Karlson, Luepker, & Herlitz, 2002; McNally, 2011). The leading causes of SCA are associated with CVD and coronary heart disease (Zheng, Croft, Giles, & Mensah, 2001; Zipes, 2004) accounting for up to 80% of sudden cardiac deaths (Myerburg, 1987; Myerburg & Castellanos, 1992). Mortality data for 2006 reported by the American Heart Association (2009) indicates that nearly 2,300 Americans die of CVD each day. CVD accounted for 34.3% of all deaths that year, or 1 in every 2.9 deaths in the United States. The preliminary data for 2007 showed that 151,000
Americans who died from CVD were less than 65 years of age. Nearly one-third of all CVD-related deaths occurred before the age of 75 years, which is well below the average American life expectancy of 77.7 years. Coronary artery disease is the cause of nearly 1 in every 6 deaths in the United States. “Approximately every 25 seconds, an American will have a coronary event, and approximately every minute someone will die from one” (p. e-47). Unfortunately, for as many as 20% of patients with coronary disease, the first clinical manifestation is SCA (Engdahl, Holmberg, Luepker, & Herlitz, 2002).

Because SCA is so often linked with coronary vascular disease, many of the risk factors are the same including hypertension, smoking, high cholesterol levels, diabetes, and obesity (Mayo Clinic staff, 2010). The prevalence and control of these traditional risk factors remains an issue for many Americans (American Heart Association [AHA], 2010). Data from the National Health and Nutrition Examination Survey 2003-2006 indicate that 33.6% of adults over the age of 20 have hypertension. In 2008, 23.1% of men and 18.3% of women over the age of 18 report being cigarette smokers. Among high school students in grades 9 through 12, 21.3% of male students and 18.7 of female students reported current tobacco use. Additionally, 46.4% of the non-smoking population had detectable serum cotinine indicating exposure from secondhand smoke. An estimated 35.7 million American adults over the age of 20 have total serum cholesterol levels above 240mg/dL, and 17.2 million have been diagnosed with diabetes. Further, the prevalence of overweight and obesity in the United States is 144.1 million, which represents 66.3% of the population over age 20. Fully 32.9% of US adults are considered obese having a body mass index ≥30kg/m² (AHA, 2010).
Other factors that increase risk for SCA included previous history of heart attack, age, being male (Mayo Clinic staff, 2010) and race/ethnicity (Zheng et al, 2001). In a study of vital statistics mortality data from 1989-1998, Zheng et al. noted that 63% of adult cardiac deaths were defined as SCA. Further, for adults aged 35 to 44, 74% of cardiac deaths were sudden cardiac deaths. Death rates for SCA increased with age and were higher for men than for women, although age-specific SCA death rates increased 21% among women aged 35-44 years during the study period and there was no difference in SCA death rates between men and women after age 85. Death rates for SCA were twice that in the black population when compared to white, American Indian/Alaska Native, or Asian/Pacific Islander, whilst the Hispanic population had lower death rates from SCA did the non-Hispanic population.

The incidence and etiology of SCA is different in children and young athletes than in adults. Children suffer far fewer cardiac emergencies than do adults (Markenson & Domeier, 2002) and ventricular fibrillation (VF) is an uncommon cause of OHCA in children, although its occurrence increases with age (Samson, Berg, & Bingham, 2003). In young athletes, SCA is usually related to underlying structural cardiac abnormality. “Hypertrophic cardiomyopathy and coronary artery abnormalities are the most common causes of SCD in young athletes in the United States, representing 25% and 14% respectively” (Rothmier & Drezner, 2009, p. 16). An additional 20% of SCD are caused by non-penetrating, blunt force trauma resulting in ventricular arrhythmia (Maron, 2003).

Socioeconomic factors. Socioeconomic status (SES) is a measure of an individual’s, family’s, or household’s position on a hierarchical social structure based on income, education, and occupation. A person’s place on the socioeconomic ladder is
frequently implicated as a contributing factor to disparities in physical and mental health and longevity. SES “impacts health by creating barriers to regular health care, adequate housing, quality education, nutritious foods, recreational opportunities, and other resources associated with a healthy lifestyle” (City of Boston, 2009, p.1). Low-SES persons have also demonstrated poor adherence to treatments such as smoking cessation or medication, which can also contribute to the disparity in health outcomes (Franks, Winters, Tancredi, & Fiscella, 2011). The association between SES and health is “particularly striking in the case of coronary heart disease” (Steptoe & Marmot, 2005, p. 133) and is consistent among adults of every age and both sexes (Clark, DesMeules, Luo, Duncan, & Wielgosz, 2009).

As discussed, poor cardiovascular health is linked to incidence of sudden cardiac arrest. Several studies have explored whether there is a direct association between low-SES and sudden cardiac arrest given the prevalence of CVD in low-SES populations. One such study found a 30 to 80% higher incidence of sudden cardiac arrest among residents of neighborhoods in the poorest SES quartiles compared to neighborhoods in the highest SES quartiles (Reinier et al., 2006). “The gradient was significantly steeper for patients under age 65 years versus over age 65 years” (p. 190). A similar but much larger multi-center observational study confirmed the disparity of incidence of sudden cardiac arrest across socioeconomic quartiles (Reinier et al., 2011). An examination of clusters of OHCA in Rochester, New York found that cluster areas had a lower median household income, more residents of African American race, and lower educational attainment (Lerner, Fairbanks, & Shah, 2005). SES has also been shown to have an inverse relationship with bystander CPR and survival rates in OHCA (Vaillancourt, Lui,
DeMaio, Wells, & Stiell, 2008). An individual level, though not an area level, measure of SES predicted survival following OHCA in a single study (Clarke, Schellenbaum, & Rea, 2005).

SES is such a strong predictor of health that an assessment of sudden cardiac arrest incidence and outcomes in Mesa would not be complete without consideration of the SES status of its residents. Overall, Mesa compares favorably on most measures of SES compared to statewide and national percentages. According to QuickFacts by the U.S. Census Bureau, “persons below the poverty level” between 2006 and 2010 was 11.9% in Mesa, compared to 15.3% in Arizona and 13.9% nationally. Eighty-six percent of Mesa residents had a high school diploma or its equivalent, slightly higher than the 85% in both the U.S. and Arizona. However, Mesa does have a number of low-to-moderate income (LMI) neighborhoods. Figure 1 provides a visual of LMI 2010 census block groups in Mesa. LMI census block groups have 51% or greater households at or below 80% of the area median income. The per capita income in the past 12 months has also been lower in Mesa when compared to statewide and national average at $24,647, $25,680, and $27,334, respectively.

Although death rates from CVD among the Mexican American population tend to be a little lower than the total population averages, SES disparities may place them at greater risk in a variety of health factors that may lead to SCA. For instance, Hispanics, in general, tend to have lower educational attainment, are more likely to be employed as operators or laborers, and have higher rates of unemployment and families living below the poverty level (Sorlie, 2004). In Arizona, "[n]early half - 46% - of people living below
the poverty level are Hispanic” (Hart & Hager, 2012, p. 31). These SES factors, coupled with lack of health coverage, language barriers, and questions of residency status, result in reduced access to preventative health care and poor management of chronic conditions. Among Mexican Americans:

Risk factors of hypertension and high cholesterol are similar to the total population average, but the numbers whose hypertension is under control is vastly different, with a third as many Mexican Americans under control. More Mexican Americans are obese and the rate is increasing. This situation presents an opportunity to prevent a CVD epidemic. (Sorlie, 2004, p. 8)

**Social Isolation.** Studies over the past few decades have explored the impact of socio-demographic factors on social isolation, particularly as it relates to chronic illness.
morbidity and mortality. Issues of socioeconomic factors (education level and employment status), gender, and marital status have all been shown to affect social isolation (Biordi & Nicholson, 2008). An increasing number of seniors may be susceptible to the social isolation and its negative health consequences. Retirement, loss of a spouse, living alone, mobility problems, having a small social networks, or an overlapping of these factors may bring about social isolation. Klinenberg’s (2002) “social autopsy” of the 1999 Chicago heat wave highlighted the importance of neighborhood characteristics finding that poor, institutionally abandoned (and socially disconnected) neighborhoods had higher mortality rates than similarly poor neighborhoods with strong social connections; seniors who where physically or socially isolated were particularly vulnerable. Many of the heat wave victims died at home – alone. An article by Bummett et al. (2001) provides confirmation that coronary artery disease patients with characteristics of social isolation are at elevated risk for mortality. Male survivors of acute myocardial infarction classified as being socially isolated were shown to have four-times the risk of death, including sudden cardiac death (Ruberman, Weinblatt, Goldberg, & Chaudhary, 1984).

**Geographic Patterns of Out-of-Hospital Cardiac Arrest**

**Residential versus public incidence.** By far, the most frequent location for OHCA is in the home (Engdahl et al., 2002; Bardy et al., 2008). Statistics reported on the frequency of in-home cardiac arrest range from three-quarters (Eisenberg & Mengert, 2001; Pell et al., 2002) to 80% (AHA, 2011) of all OHCA incidents. Out of the 31,689 OCHA cases reported to CARES from October 1, 2005 to December 31, 2010, approximately 66.4% occurred in the home and 13.5% occurred in a nursing home.
assisted living facility, the remaining OCHA events (20.1%) occurred in public places (McNally, 2011). A number of studies have looked more closely at public locations for SCA in an effort to target AED placement and lay responder training.

The Occupational Health and Safety Administration (OSHA) reports that approximately 10,000 of the 220,000 cases of SCA reported annually occur in the workplace (Occupational Safety and Health Administration [OSHA], n.d.). In 2001 and 2002, 6,628 workplace fatalities were reported to OSHA, of these 1,216 were cardiac events (OSHA, n.d.). Data collected in multi-year retrospective studies conducted in Calgary, Alberta, Canada (Millard, De Maio, Grant, & Yahn, 2000) and Seattle (Ornato & Hankins, 1999) showed that 13% to 16% of SCA events occurred in a public location. An examination of all cardiac arrests in Copenhagen, Denmark from 1994 through 2005 documented the highest rates of OHCA in areas containing major bus and train terminals, high-density public areas, large shopping centers, and sports arenas (Folke et al., 2009). Other studies have shown airports (Becker et al., 1998), casinos (Valenzuela et al., 2000), and fitness centers and golf courses (Reed et al., 2006) to be high-probability sites for OHCA incidents. Becker et al. (1998) defined high-risk locations as those with an incidence of OHCA of ≥ 0.03 per site, or one or more arrests per 30 sites in one year. Among the high incidence sites identified were airports, prisons, shopping malls, and sports arenas.

Other studies suggest, however, that SCA may be a much more random event making it difficult to estimate the annual risk of cardiac arrest in a given property use or specific location. A five-and-a-half year retrospective review involving 940 cardiac arrests in a rural area found that “no location had more than two OHCAs” and “most non-
residential OCHAs occurred as isolated events in 146 different locations” (Portner, Pollack, Schirk, & Schlenker, 2004, p. 352). Similarly, a six-and-a-half year study in a suburban system identified only three public locations where more than one cardiac arrest occurred: a golf course, a YMCA, and a health club (Cooper, Swor, Jackson, & Chu, 1998). In an analysis of 922 cardiac arrest cases in Kansas City, Missouri for calendar year 1997, Gratton et al. (1999) found only 16 locations had multiple OHCA incidents: “11 locations had two cardiac arrest, four locations had three cardiac arrests, and one locations had four cardiac arrests” (p. 304). Also noteworthy, is that while the Kansas City International Airport had two cardiac arrest incidents, these occurred approximately four miles apart.

The studies by Portner et al. (2004) and Gratton et al. (1999) noted that nursing homes and extended-care facilities account for a significant portion of sites with multiple cardiac arrest incidents. However, the prognosis for these patients was poor. Awoke, Mouton, and Parrott (1992) examined outcomes for extended-care patients receiving ACLS treatment during cardiac arrest, there were no survivors to hospital discharge. To be cost effective, extended-care facilities would need to have a SCA survival rate of 25% (Foutz & Sayre, 2000). Data provided by McNally et al. (2011) demonstrate a 3.7% survival rate among nursing home and assisted living patients, the lowest survival rate by location except for farms. Similarly, Weisfeldt et al. (2011) found an OHCA survival rate of only 3% in residential institutions (e.g. nursing homes) and other private (non-home) settings.

Survival from OHCA is higher when the event occurs in a public location. In an early study of the effect of location of OHCA on survival, Litwin, Eisenberg, Hallstrom,
and Cummins (1987) noted that 27% whose arrest occurred in a public place survived compared to only 13% of patients who experienced cardiac arrest at home. The authors attribute this difference to the fact that patients who collapse outside the home tended to be younger, had fewer symptoms prior to arrest, and were more likely to have a presenting arrest rhythm of VF. They also noted that patients who arrested in public were more often witnessed and therefore, more likely to receive bystander-CPR. Patient survival rates in the CARES database range from 2% to 35% depending on the location of the OHCA event (McNally et al., 2011). Survival was highest when arrests occurred in recreation/sports facilities (28.9%), physician offices/clinics (26.9%), educational institutions (25.3%), or public buildings (23.3%); outcomes were poor in homes (7.6%) where most OHCA events occurred. A recent study (Weisfieldt et al., 2011) documented a rate of survival to hospital discharge as high as 34% for OHCA in public settings versus 12% for arrests at home when a bystander applied an AED; the survival rates dropped to 20% and 8% respectively in bystander witnessed cardiac arrest when no AED was applied.

**Neighborhood level spatial analyses.** A better understanding of neighborhood-level patterns in the distribution of OHCA may identify opportunities to direct public health education, CPR training, and public access defibrillation placement. Data compiled by the ADHS have explored socioeconomic and demographic characteristics of populations in relation to coronary heart disease and CVD, but these data are reported on a statewide level. Maricopa County reports a myriad of health statistics for cities and towns, but not to the level of census tract or census blocks, and not for sudden cardiac arrest.
Recent spatial analyses of the incidence of cardiac arrest have defined neighborhoods as census tracts, or equivalent geographic unit. In the U.S., census tracts are statistical geographic subdivisions within a county that typically include 1,500 to 8,000 people, with an average size of about 4,000 people, and are intended to represent homogeneous neighborhoods with respect to population characteristics, economic status, and living conditions (U.S. Census Bureau, n.d.). These characteristics are useful in identifying disparities in health risks and outcomes. Three studies using U.S. and Canadian census tracts (Reinier et al., 2011; Sasson et al., 2012; Sasson et al., 2010) and a study from Singapore using development guide plan (Ong et al., 2011), an equivalent to census tract level, all identified clusters of OHCA using a variety of spatial analysis and statistical methods.

Only one study (Lerner, Fairbanks, & Shah 2005) was found that used census block groups in identifying high-risk neighborhoods for sudden cardiac arrest. Census block groups are smaller than census tracts containing between 600 and 3,000 people, with an optimal size of 1,500 people (U.S. Census Bureau, n.d.). As a smaller unit of analysis, census block groups tend to be modestly more homogeneous than larger census tracts and, therefore, may be a better proxy for neighborhood.

**Programs to Promote Cardiovascular Health and Prevent Sudden Cardiac Death**

**Public health outreach and education.** Community-based intervention is a critically important method of achieving a goal of reducing the burden of CVD and SCA. A number of community-based programs have used a combination of interventions to try to modify both individual behavior and encourage community-wide lifestyle changes that promote greater cardiovascular health. These programs sought to reduce the burden of
CVD and its antecedent risk factors such as poor nutrition, physical inactivity, tobacco use, and hypertension. Some of the larger programs include the Pawtucket Heart Health Program (Carleton et al., 1995), the Minnesota Heart Health Program (Luepker et al., 1994), and the Boothheel Heart Health Program (Brownson et al., 1996). In a discussion of the results of a quasi-experimental assessment of the Bootheel program, the authors noted that, "[e]ven with modest resources, community-based programs show promise in improving behaviors related to cardiovascular disease within a brief period" (Brownson et al., 1996, p. 210). They site additional research from similar programs that demonstrated measurable improvements in dietary fat consumption, cholesterol awareness and screening, and physical activity.

Conclusions from the Pawtucket and Minnesota were more cautious noting that, while positive trends in cardiovascular health were observed, the program effects failed to reach statistical significance (Luepker et al., 1994; Carleton et al., 1995). It was suggested that while "achieving cardiovascular risk reductions at the community level was feasible . . . accelerating risk factor changes will likely require sustained community effort with reinforcement from state, regional, and national policies and programs" (Carleton et al., 1995, p. 777). Indeed, integrated community health approaches that promote strong partnerships, community engagement, and targeted actions appear to be key to reducing health disparities. For example, the Chicago Southeast Diabetes Community Action Coalition was established as a minority research center, mostly to address diabetes, cancer, and tobacco-related diseases. The Coalition worked with hospitals to establish centralized data tracking; health promotion was targeted to at-risk populations identified through community mapping. Strong community partnerships were
forged with religious organizations, professional groups, government agencies' and hospitals to become advocates for social change. Outreach programs included workshops, health fairs, exercise-related programs, and other community health awareness and education projects (Giachello, 2004).

**CPR Training.** Immediate recognition of cardiac arrest, prompt activation of the EMS system, and rapid initiation of effective chest compressions are fundamental components of cardiac arrest resuscitation. Bystanders should start CPR immediately if the victim is unresponsive and not breathing, or has ineffective agonal gasps. OPALS represents one of the largest multicenter studies of pre-hospital cardiac arrest conducted. Of the potentially modifiable factors associated with survival (which included bystander CPR, police or fire CPR, and ambulance response time), OPALS found that bystander CPR had the strongest association with survival to hospital discharge (Stiell et al., 1999).

There has been considerable concern about the bystander’s willingness and ability to perform CPR. One survey of attitudes toward CPR of family members of patients with heart disease found reported barriers to performing CPR included fear of harming the patient or lack of knowledge and skills to help (Platz, Scheatzle, Pepe, & Dearwater, 2000). This same study reported that while 49% of family members had received initial CPR training, only 7% maintained their skills through refresher training. Vallancourt, Stiell, and Wells (2008) sought to understand and improve low bystander CPR rates. They classified 22 recommendations for improvement, “those with the highest scores were 1) 9-1-1 dispatch assisted CPR instructions, 2) teaching CPR to family members of cardiac patients, 3) Braslow’s self-training video, 4) maximizing time spent using manikins, and 5) teaching the concepts of ambiguity and diffusion of responsibility” (p.
Not supported by their evidence was mass training events or compression-only CPR.

However, more recent research has demonstrated the effectiveness of the compression-only approach. The AHA has been progressively moving away from compression-to-ventilation ratios placing emphasis on chest compressions. The current standard calls for continued compression-only CPR until an AED arrives and is ready for use. “Hands-Only (compression-only) CPR is easier for untrained rescuers to perform and can be more readily guided by dispatchers over the telephone (AHA, 2010, p. 6).

Layperson compression-only CPR has been associated with increased survival when compared with conventional CPR and no-bystander CPR in the out-of-hospital setting (Bobrow et al., 2010). Dispatcher-assisted bystander CPR has shown to increase survival in cardiac arrest (Rea, Eisenberg, Culley, & Becker, 2001). In fact, the new 2010 AHA Guidelines for CPR and ECC strongly recommend that dispatchers instruct untrained lay rescuers of providing hands-only CPR (AHA, 2010).

People who experience CPR training have a greater tendency to perform bystander CPR in an emergency (Tanigawa, Iwami, Nishiyama, Nonogi, & Kawamura, 2011). Classes can be delivered one-on-one, in small groups, or en masse, and course material distributed through traditional classroom instruction or computer-based training. The method of delivery is important as there has been some concern that computer-based CPR training, while able to reach more people in the community, may not be as effective as classroom training in terms of the quality of CPR performed (Rehberg, Diaz & Middlemas, 2009), although results appear to differ (Lynch et al., 2005). The quality of bystander CPR has been shown to be associated with patient survival (Gallagher,
Lombardi, & Gennis, 1995). Some experts suggest that annual refresher training is important for the retention of core skills (Wik, Dorph, Auestad, & Steen, 2003; Aufderheide et al., 2006). Riegel (1998) believes that since CPR can be a difficult skill to learn, the best delivery is through small class sizes that afford greater student-instructor interaction. Still, Web-based and blended learning programs appear to be gaining acceptance.

Public Access Defibrillation. Early defibrillation intervention in SCA is a critical component of the chain of survival because the chance of survival diminishes the longer the time between arrest and defibrillation (Valenzuela et al., 2000; Chan, Krumholz, Nichol, & Nallamothu, 2008). In an evaluation of a resuscitation outcomes consortium population of 21 million, application of AED by trained lay volunteers was associated with near doubling of OHCA survival (Weisfeldt et al., 2010). The AHA continues to “recommend the establishment of AED programs in public locations where there is a relatively high likelihood of witnessed cardiac arrest (eg, airports, casinos, sports facilities)” (AHA, 2010, p. 9).

Atkins (2010) and Caffrey (2002) define multi-tiered typologies of public access defibrillation programs. These typologies can be used to help focus the discussion on the potential strengths and weaknesses of each model. In general, efforts to increase access to early defibrillation can be divided into four models based on the characteristics of the rescuer: traditional first responders, non-traditional first responders, laypersons (in-home defibrillation), and community programs.

Traditional first responder AED deployment. Traditional first responders include those professionals that have a duty to respond, such as police officers, firefighters, and
Emergency Medical Technicians (EMT). Studies have documented decreased time-to-defibrillation interval and improved patient survival to hospital discharge when police respond with AEDs (Mosesso, Davis, Auble, Paris, & Yealy, 1998; Myerburg et al., 2002; Agarwa, Hess, Atkinson, & White, 2009). One study noted that survival to hospital discharge was higher among those defibrillated by police (58%) compared to paramedics (43%), with an overall survival rate of 49% (White, Asplin, Bugliosi, & Hankins, 1996). However, other studies have found a lack of survival benefit from police deployed AEDs in urban areas when fire-based first-responders were equipped with defibrillators (Sayre, Evans, White, & Brennan, 2005), or in suburban and rural settings when police response times were poor (Groh, Newman, Beal, Fineberg, & Zipes, 2001).

**Non-traditional first responders.** Nontraditional responders – including security guards, lifeguards, and flight attendants – provide an opportunity to cost effectively enhance community response to SCA events. The best results are achieved when AEDs are placed in areas where there is a high density of potential victims, high frequency of OHCA, and a supervised program with emergency plans and recurring CPR-AED training (Atkins, 2010; Winkle, 2010). Not all high-efficacy public locations will yield positive results. For example, based on the results of their study, Gratton et al (1999) recommended that nursing homes consider AED availability. Yet, studies suggest that few nursing home residents would benefit from such interventions (Tresch, et al., 1993; Benkendorf et al., 1997; McNally et al., 2011).

**Laypersons (in-home defibrillation).** A third level of AED deployment is to provide devices to patients at high-risk of SCA (Atkins, 2010) as a means of improving survival of cardiac arrests that occur at home. Carm, Vijan, Katz, and Fendrick (2004)
suggest that in-home placement of AEDs was economically feasible, but cost-effectiveness is “intimately linked to an individual’s risk of cardiac arrest” and accurately predicting individual risk for SCA was described as “difficult” (p. 256). The presence of an AED in the home seems to positively effect the quality of life for both patients and their significant others (Chen, Eisenberg, & Meishke, 2002; Mark et al., 2010). However, the Home Automated External Defibrillator Trail (HAT) ultimately concluded that a home AED did not significantly improve survival, as compared with standard resuscitation methods (Bardy et al., 2008).

**Community Public Access Defibrillator Programs.** With defibrillators becoming increasingly simple to use, communities have began to place units in public locations where large groups of people congregate, such as shopping malls, sports arenas, community centers, and international airports. Programs at Phoenix Sky Harbor International Airport (Huff, 2011) and three Chicago airports (Caffrey, Willoughby, Pepe, and Becker, 2002) found that defibrillators in readily accessible, well-marked public areas were indeed used by good Samaritans, acting voluntarily, saving dozens of lives.

This success has led some to call for AEDs to be placed in public locations in a manner patterned after fire extinguishers (Capucci & Aschieri, 2011). But experts question the efficacy of this strategy. Atkins (2010) cites several publications that illustrate the limitations of unguided AED placement. For example, data from Austria’s nationwide PAD program documented that although 1,865 devices were installed, in a two-year period they were accessed in only 73 OHCA events (Fieischhackl et al., 2008). Similarly, Folke et al (2009) found that unguided placement led to AEDs being placed in
locations at extremely low risk of OHCA, where they had no impact on survival.

Conversely, properly designed PAD programs focused on sites known for high incidence of OHCA have demonstrated improved survival from VF when treated by an on-site AED (Colquhoun et al., 2008; Folke et al., 2009). Yet, the results of a retrospective cohort study in Scotland has at least one group of authors questioning the potential impact of PAD in general:

The predicted increase in survival from targeted provision of public access defibrillation is less than the increase achievable through expansion of first responder defibrillation to non-ambulance personnel, such as police or firefighters, or of bystander cardiopulmonary resuscitation. Additional resources for wide scale coverage of public access defibrillators are probably not justified by the marginal improvement in survival. (Pell et al., 2002, p. 515)

**Summary**

SCA continues to be a major public health problem. Researchers have found that the majority of SCA events have a cardiac etiology. Because SCA is so often linked with heart disease, many of the risk factors are the same including hypertension, smoking, high cholesterol levels, diabetes, and obesity. Other factors that increase risk for SCA include previous history of heart attack, age, being male, and race/ethnicity. SES has also been linked to cardiovascular disease, but its influence on outcome from OHCA is not well understood. While persons of Hispanic descent, in general, appear to be at lower risk for CVD, SES disparities may place them at greater risk for a variety of health factors that lead to SCA. No past literature was identified that explored this association directly. This link is important to Mesa, Arizona given the city’s sizeable Mexican
American population. Classic epidemiology can provide useful information regarding the risk of OHCA in communities and possible approaches to prevention.

Statistics report that between three-quarters to 80% of all OHCA occur in the home. For the remaining episodes that occur in public places, large shopping centers, transportation hubs, casinos, sports arenas, and fitness centers have demonstrated to be high-yield locations. Survival from OHCA is higher when the event occurs in a public location making them frequent targets for prevention programs. However, some experts suggest that OHCA is a much more random event making it difficult to estimate the annual risk of SCA in a give property use or specific location. Spatial analysis has been used to identify clusters of OHCA and understand disparities in health risks and outcomes. There have been only a handful of studies that have explored the incidence of OHCA in lower SES neighborhoods. Most of these used census tracts as a proxy for neighborhood, however census blocks may prove to be a better substitute since they are smaller units of analysis that tend to be modestly more homogeneous.

Efforts to reduce sudden cardiac death have typically focused on community health outreach and education, bystander CPR training, and wider availability of AEDs. The literature demonstrates mixed results for all of these interventions. Heart health programs have demonstrated some ability to reduce the antecedent risk factors associated with CVD and SCA; but most failed to attain statistical significance. In the event of SCA, bystander CPR has demonstrated the greatest association to patient survival; however, the rate of bystander CPR varies considerably regionally and between areas within cities. A substantial body of evidence demonstrates improved survival resulting from reduced time to defibrillation with PAD programs; yet, unguided placement has
proven ineffective and optimal deployment of AEDs appears to depend on individual community characteristics. Therefore, the most successful prevention program to reduce premature death due to SCA would be one that is tailored to the specific needs of community and targets at-risk populations and high-incidence locations.

**Procedures**

This applied research project involved a retrospective study of OHCA events in the city of Mesa. All data were obtained from a database of MFMD electronic patient care reports. This system went operational in October 2010. Moving from handwritten paperwork and manual data entry to ePCR provides several benefits to the department including instant access to quality, standardized data. Every effort was made to de-identify patient data so that it was no longer protected health information subject to the Health Insurance Portability and Accountability Act (HIPPA) privacy rule, and would therefore be considered exempt research by an Internal Review Board.

**Literature Review.**

The literature review contained herein provides an account of what has been published by scholars, researchers and epidemiologists on the morbidity and mortality of OHCA, as well as the efficacy of public health interventions that have been explored to improve patient survival. The purpose was to offer an overview on the existing body of literature published on this topic. In support of the literature, information regarding the finding of past clinical studies from related fields was presented. This literature identified areas of prior scholarship, shed light on gaps in previous research, and pointed the way toward an appropriate methodology that could be applied to analyze and describe the incidence of OHCA in Mesa.
Research began at the Learning Research Center (LRC) at the National Fire Academy in Emmitsberg, Maryland. The LRC is a small research library that maintains a collection of applied research materials, books, and trade publications specific to fire and emergency services. The LRC online catalogue and EFOP Applied Research Projects Portal provided distance access to library materials. Additional materials were obtained from the ASU libraries. ASU provides access to programs in public health through a partnership with the University of Arizona College of Medicine and the Mel and Enid Zuckerman Arizona College of Public Health. The ASU libraries’ online service “One Search” accesses dozens of top research databases, including 41 related to public health such as PubMed Central and MEDLINE. Search engines accessed included Google, Google Scholar, and the Mesa Council, Board and Committee Research Center.

**Study Setting**

The city of Mesa has a population of 439,041 people (U.S. Census, 2010) within an incorporated area of 137 square miles. Mesa is the third largest city in the State of Arizona and is located east of the city of Phoenix within Maricopa County, one of the fastest growing metropolitan regions with over 3.8 million residents. The City ranks as the 39th most populous city in the United States, larger than Kansas City, Miami, and Pittsburgh. Seventy-seven percent of citizens classified as white, 26.4% as Hispanic ethnicity, and 3.5% African American by the U.S. Census Bureau. Fourteen percent are foreign-born persons, and 22.1% speak a language at home other than English. Nearly 12% of the population earns an annual income below the poverty level. Seniors over age 65 now make up 14.1% of the population. Twenty-three percent of homeowners and 32.2% of renters report living alone.
The city of Mesa is serviced by a fire-based EMS system. The MFMD is generally responsible for all "first response" emergency medical activities. All four-person MFMD response units are staffed with two paramedics (Mesa Fire Department [MFD], 2006) with a 12-lead ECG and defibrillator being part of the standard inventory. A private ambulance company provides emergency transportation services for the city through a multi-jurisdictional regional contract. Ambulances are staffed by two Arizona certified EMTs, at least one of which is certified as a paramedic. These units are equipped with a defibrillator and are capable of initiating ACLS treatment when their arrival precedes that of the MFMD. Mesa police may also respond to cardiac arrest events and officers receive biennial CPR training, however patrol units are not currently equipped with an AED. Access to emergency services is gained through a single, government-operated, public safety answering point. Operators are capable of providing dispatcher-assisted CPR instruction in response to an OHCA call. The MFMD responded to 54,831 incidents in 2010, 40,118 were for medical events (MFD, 2011).

Data Abstraction

Data were abstracted from EMS patient care reports of cardiac arrest in Mesa, Arizona for the period of October 1, 2010, through March 31, 2012. The ePCR templates completed by EMS personnel ensure standardized reporting of data (Figure 2). Data were included on any persons of any age who had an OHCA event and who received cardiopulmonary resuscitative efforts. To be included in the analysis, the event must have occurred due to a presumed cardiac etiology according to the clinical assessment of the paramedics. Trauma cases were excluded from the analysis presumably because
defibrillation is not the first priority for most of these patients. Patients with a “do not resuscitate” order were also excluded. Finally, non-cardiac events (i.e. overdose, respiratory arrest, anaphylaxis, etc.) were excluded, except that such non-cardiac events may be discussed as part of the characteristics of all episodes.

Patient-level characteristics were also obtained from the patient care reports. These included age, gender, location of the arrest (property use code), witness arrest, who initiated CPR (bystander versus first responder), AED prior to EMS arrival, initial cardiac rhythm, and receiving hospital. Response times recorded included call received, dispatched, en route, on scene, patient contact, left scene, and at destination (hospital arrival time). Patient treatments and administration times were included, as was the return of spontaneous circulation, when applicable. Incident numbers were entered into the Firehouse database to obtain a physical address to be geocoded for GIS analysis.
Census block groups were used as a proxy for neighborhoods as they tend to represent social and economically homogeneous groups with an optimal size of about 1,500 people (U.S. Census Bureau, n.d.). Census block group shapefiles, block group populations, and demographic and socioeconomic data were obtained from the U.S. Census Bureau. The following factors were then added to the existing data set based on the geocoded location of the OHCA event: (1) percentage of whites, African Americans, and nonwhite Hispanics, (2) percent speaking a language at home other than English, (3) percent living below the poverty line, (4) percent of elderly, (5) percent living alone, (6) percent of elderly living alone, and (7) percent female. Abstracted and census data were entered into a Microsoft Excel (Redmond, WA) spreadsheet for analysis.

**Data Analysis**

The OHCA dataset was geocoded to city of Mesa parcels based on the incident address using ArcGIS 9.3 software (www.esri.com). Out of a total of 372 cases, 356 (96.5%) were located within a parcel matching the incident address. The remaining 16 cases either had unknown or incomplete addresses, or the address was outside of the city of Mesa and beyond adjacent cities’ public safety service areas. A GIS spatial join operation was used to complete the sum of all cases within each census block group in the city and estimate a simple incidence rate (not adjusted for age) of OHCA events in the general 2010 population. Socioeconomic and demographic variables at the census block level were linked to each geocoded address using the 2010 U.S. Census Bureau summary files. Descriptive data related to patient treatment and transport were associated with each address. A thematic map was created with different colors representing different densities of incidents.
Bivariate analysis was conducted using Spearman’s correlation coefficient (two-tailed) to check the covariance of census variables that were expected to relate to OHCA incidence. Spearman’s is a non-parametric statistic and so can be used when the data have violated parametric assumptions and is therefore suitable for non-normally distributed data (Field, 2005). Some variables were excluded from the final analysis as they were superfluous or were complemented by other variables (e.g. the coefficient of percent Non-Whites is inversely correlated to percent White).

A principal component analysis (PCA) was conducted on the remaining variables that were statistically correlated with OHCA. “Principal component analysis is a statistical technique that linearly transforms an original set of variables into a substantially smaller set of uncorrelated variables that represent most of the information in the original set of variables” (Dunteman, 1989, p. 7). From this dataset, two principal components were extracted. Component 1 was derived from the profile of the general population and housing characteristics including sex (percent female), age (65 years and older), and households by type (householder living alone). This was labeled as an “Age and Social Isolation” factor. Component 2 is made up selected social and economic characteristics including race (non-White), linguistic isolation (percent not speaking English), and percent in poverty. This was called an “Immigrant” factor. One of the outputs of the PCA is a z-score for each census block group and each principal component. These scores were rescaled based on standard deviations to compute a standardized OHCA risk score for each census block group based on the method presented in Reid et al. (2009). This allowed high-risk areas to be plotted.
The next step was to put the OHCA risk index to the test and assess how good it is in predicting the observed OHCA incidence. Toward this end, three Local Indicators of Spatial Analysis (LISA, Anselin, 1995) were conducted: OHCA incidence versus the Immigrant Factor, OHCA incidence versus the Age/Social Isolation Factor, and OHCA incidence versus the combined OHCA vulnerability index. Color coded maps were then generated to graphically depict areas of high- and low-incidence of OHCA based on these components.

**Estimating Risk at Public Locations**

A portion of this research project sought to describe the public locations of OHCA and estimate the annual incidence of cardiac arrest per site in order to determine if there were public occupancies within the city that could benefit from a PAD program. This method employed was adapted from Becker et al. (1998). A public location was defined as an indoor commercial or civic facility or outdoor space except for immediately outside of a patient’s home. High-risk sites were defined as those with ≥.03 incidence per year per site (one arrest per 30 sites in one year), and low-risk as sites locations with ≤.01 per year per site (one arrest per 100 sites in one year). Since only 18 months of ePCR data were available, medical records for non-traumatic OHCA were abstracted from the Firehouse database for the period of January 2007 to September 2010. Added to the ePCR data, this provided a 5-year longitudinal observation of OHCA in Mesa.

Addresses were cross-referenced with the MFMD Fire Prevention Bureau database to classify locations based on the National Fire Incident Reporting System (NFIRS) public use property codes and descriptions. The MFMD Fire Prevention Bureau routinely uses NFIRS for reporting fire statistics, ordering priorities for inspections, and
measuring the effectiveness of loss prevention programs directed at specific property
types. Section J of NFIRS, version 5.0, categorizes property use into nine property use
codes: assembly; educational; health care, detention, and correction; residential;
mercantile, business; industrial, utility, defense, agriculture, mining; manufacturing,
processing; storage; and outside or special property.

Each public use code contains additional sub-categories that provide more
specific definitions of property use. For example, 100-Assembly includes 111-Bowling
establishment; 300-Health Care, Detention and Correction contains 311-Nursing homes
licensed by the state, providing 24-hour care for 4 or more persons. Since property codes
are input manually, they are subject to a degree of interpretation and human error. To
ensure property uses were consistently identified, addresses were checked and
reclassified when there was consensus among the author, a member of fire prevention,
and an EMS officer. In one instance, recreation centers in active adult communities were
classified as 110-Fixed use recreation; 120 Variable use amusement, 121-Ballroom,
gymnasium; and 142-Clubhouse. These were all re-classified as 142-Clubhouse for the
purpose of this analysis.

Limitations and Delimitations

This study focused on cardiac arrest as the dependent variable. Certainly, SES
and social isolation factors may affect other medical conditions. The reason for selecting
OHCA was that the Mesa City Council was interested in exploring the efficacy of a PAD
program as part of Project Heart Beat and had requested information on what areas of the
city might best be served by such an ordinance. With these results, the Council can make
an evidence-based decision of public AED availability. The best medical outcomes from
the use of an AED usually result from a sudden cardiac arrest due to a cardiac etiology; therefore, only OHCA of cardiac origin were included in the study. It is possible that sudden cardiac arrests due to other causes may be correlated to factors and principle components explored here. This is especially true for data obtained from the Firehouse database. Hospital records or autopsy reports were not available to confirm the underlying cause of the cardiac arrest. It is also possible that a small minority of the OHCA incidents included in the analysis had a non-cardiac cause such as aortic rupture or pulmonary embolism that was not identified by EMS personnel.

Another potential limitation is that there are other individual and neighborhood risk factors that can contribute to OHCA rates than those included here. Patients who suffer a sudden cardiac arrest have a variety of clinical co-morbidities such as cardiovascular disease, obesity, and hypertension that can increase risk and complicate survival outcome. Neighborhood factors such as access to quality food, environmental factors such as air pollution levels and extreme temperatures, and personal habits such as smoking, may also contribute to morbidity and mortality. Furthermore, SES measures used in this analysis were at the block group level. While census block groups are intended to be homogenous, individual-level measures of SES such as income, educational attainment, or occupation were not available and may not be accurately represented by the block group in all cases.

Data were also missing from ePCR reports, especially during the first few quarters after its adoption in October 2010. For example, some reports were missing data on pre-arrival bystander actions and others failed to document the initial rhythm found by arriving paramedics. Changes to reporting requirements in the ePCR software and
Spatial Cluster Analysis

Further paramedic training on completing ePCR reports was done by the MFMD and is reflected in more complete information in the later quarters of the study period. The missing data may affect the results of the analysis.

Finally, census characteristics correlated to the incidence of OHCA were identified using PCA rather than a factor analysis. While both techniques are linear models with the "common aim of reducing the dimensionality of a variable set" (Dunteman, 1989, p. 55), these techniques "differ in the communality estimates that are used" (Field, 2005, p. 630). Only factor analysis derives a mathematical model from which factors are estimated, thus it may be considered a more accurate technique for identifying underlying factors. However, PCA is a "psychometrically sound procedure" that is "conceptually less complex than factor analysis" (p. 631).

Results

Public health education, CPR training, and AED placement have the potential to improve survival rates from cardiac arrest. But the incidence and outcomes of OHCA can vary widely across cities. Determining which neighborhoods and public locations have the highest rates of OHCA could provide promising targets for community-based interventions. This section presents the results from a retrospective review of the data and spatial cluster analysis in terms of the four research questions posed in the Introduction.

Question 1. *What is the morbidity and mortality of out-of-hospital sudden cardiac arrest in Mesa, Arizona?*

The MFMD responded to 372 OHCAs during the study period from October 2010 to March 2012. There was sufficient information to document location (n=344), outcome
(n=372), etiology (n=302), witness status (n=268), bystander CPR (n=304), and AED prior to arrival (n=59). Table 1 presents the characteristics of OHCA in Mesa, Arizona. In all cases, the mean age of OHCA patients was 62.8 (±21.3); this is slightly younger than the mean age of 64.0 years (±18.2) documented in the CDC CARES registry (McNally et al., 2011). Paramedics reported “cardiac” as the suspected etiology in 73.5% (n=227) of cases, followed by “other” (n-35), respiratory (n=34), trauma (n=5), and electrocution (n=1). The majority of OHCAs occurred in residential locations (n=232), while 32.6% (n=112) took place in public places. Statistics report the frequency ofTable 1.

Characteristics of Out-of-Hospital Cardiac Arrest in Mesa, Arizona

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr), Mean (SD), (n=372)</td>
<td>62.84</td>
<td>(+21.33)</td>
</tr>
<tr>
<td><strong>Outcome (n=372)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dead After Arrival</td>
<td>60</td>
<td>16.13</td>
</tr>
<tr>
<td>Dead Prior to Arrival</td>
<td>67</td>
<td>18.01</td>
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<tr>
<td>Other</td>
<td>5</td>
<td>1.34</td>
</tr>
<tr>
<td>Treated and Transferred Care</td>
<td>233</td>
<td>62.63</td>
</tr>
<tr>
<td>Treated/No Transport</td>
<td>7</td>
<td>1.88</td>
</tr>
<tr>
<td><strong>Cardiac Etiology (n=302)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrocution</td>
<td>1</td>
<td>0.33</td>
</tr>
<tr>
<td>Other</td>
<td>35</td>
<td>11.59</td>
</tr>
<tr>
<td>Presumed</td>
<td>227</td>
<td>75.17</td>
</tr>
<tr>
<td>Respiratory</td>
<td>34</td>
<td>11.26</td>
</tr>
<tr>
<td>Trauma</td>
<td>5</td>
<td>1.66</td>
</tr>
<tr>
<td><strong>Witnessed By (n=268)</strong></td>
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<td></td>
</tr>
<tr>
<td>Bystander</td>
<td>82</td>
<td>30.60</td>
</tr>
<tr>
<td>EMS</td>
<td>28</td>
<td>10.45</td>
</tr>
<tr>
<td>Unwitnessed</td>
<td>158</td>
<td>58.96</td>
</tr>
<tr>
<td><strong>Bystander CPR (n=304)</strong></td>
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<td></td>
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<tr>
<td>No</td>
<td>263</td>
<td>86.51</td>
</tr>
<tr>
<td>Yes</td>
<td>41</td>
<td>13.49</td>
</tr>
<tr>
<td><strong>AED Prior to EMS (n=59)</strong></td>
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<tr>
<td>Bystander</td>
<td>5</td>
<td>8.47</td>
</tr>
<tr>
<td>Bystander Familiar</td>
<td>2</td>
<td>3.39</td>
</tr>
<tr>
<td>EMS</td>
<td>52</td>
<td>88.14</td>
</tr>
</tbody>
</table>
In-home cardiac arrest between three-quarters and 80% of all incidents (Eisenberg & Mengert, 2001; Pell et al., 2002; AHA, 2011), suggesting Mesa has a higher incidence of OHCA in public locations. However, as will be discussed later in this section, most arrests occurring in “public locations” were in residential care or skilled nursing facilities. Mesa OHCA frequencies appear consistent with data reported to CARES which shows 66.4% of cardiac arrests occurring in homes, 13.5% in nursing homes and assisted living facilities, and the remainder in various categories of public occupancies (McNally et al., 2011).

Unfortunately, documentation by field personnel report that most OHCAs in Mesa are un-witnessed; few patients receive bystander CPR; and only a handful of patients have an AED applied prior to the arrival of EMS. Fifty-nine percent (n=158) of OHCAs in the city were un-witnessed, 30.6% (n=82) were witnessed by a bystander, and 10.5% (n=28) observed by EMS personnel. Only 41 patients were documented as receiving bystander CPR, and only 7 had an AED applied before the arrival of EMS personnel. The lack of effective bystander interventions will certainly affect patient outcomes. For all reported OHCAs (n=372), 18.0% (n=67) of patients were reported dead prior to arrival, and 16.1% (n=60) were declared dead on arrival of EMS. Of the 233 (62.6%) patients treated and transported to area hospitals, 69 had return of spontaneous circulation in the field and 52 had vital signs upon transfer to the emergency department.
**Question 2.** Are there particular characteristics of the population that place neighborhoods at greater risk for out-of-hospital cardiac arrest incidents?

A review of the epidemiological literature identified a number of socio-demographic determinants of SCA that may be used to identify at-risk populations and explain high-incidence clusters of OHCA. Important demographic factors that have been shown to increase the risk of SCA included age, being male (Mayo Clinic staff, 2010) and race/ethnicity (Zheng et al., 2001). Death rates for SCA have been found to increase with age and are higher for men than women. African-Americans have twice the death rate from SCA when compared to other populations (Zheng et al., 2001). SES has proven to be a strong predictor of health, has an inverse relationship with bystander CPR rates (Vallancount et al., 2008), and is a predictor of survival following OHCA (Clarke, Schellenbaum, & Rea, 2005). While Hispanics have lower death rates from SCD than do non-Hispanics (Zheng et al., 2001), SES disparities place them at greater risk in a variety of health factors that could lead to SCA. Low-SES, coupled with a lack of health coverage, language barriers, and questions of residency status, results in reduced access to preventative health care and poor management of chronic conditions.

Demographic and socioeconomic risk factors identified in the literature review were compared with Mesa city data available from the 2010 U.S. Census and seven variables were selected for analysis. Table 2 presents the findings of the covariance of census variables that were expected to be related to OHCA incidence. OHCA incidence (INCIDENCE_PER_THOUSAND) is statistically correlated to all variables except for
Table 2.

Covariance Correlation Analysis

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non-English speaking (PER_NOT_SPEAK_ENGLISH) and poverty (PER_POVERTY). Positive correlations to OHCA incidence were found with percent elderly ($r_s=.272$, $P=.01$), percent of elderly living alone ($r_s=.250$, $P=.01$), and percent of population living alone ($r_s=.248$, $P=.01$); a weak negative correlation was found with percent non-White ($r_s=-.134$, $P=.05$).

**Question 3. Which neighborhoods in Mesa demonstrate a high incidence of out-of-hospital cardiac arrest but low rates of bystander-CPR?**

The results of the first research question found that only 41 patients received bystander CPR prior to the arrival of EMS responders. Because of this, bystander CPR is low citywide and the analysis was not able to identify areas with high incidence of OHCA and low rates of bystander CPR. Therefore, this research question focused on identifying neighborhoods with clusters of OHCA incidents based on census block group socio-demographic factors discussed in the literature review and examined in the second research question.

Two principle components were extracted from the OHCA risk factor variables identified in question 2. LISA analyses were conducted allowing high-risk areas of the city to be mapped. Figure 3 shows the cluster of high-risk census block groups based on demographic and socioeconomic factors associated with immigrant status and incidence of OHCA. Areas of red indicate high values for both variables, while blue areas mean low values. A 7-census block group cluster was identified west of downtown Mesa. Six of the 7 block groups in this cluster have a higher percentage of minority residents (25% to 42%; Mesa mean 22.9%) and all of the block groups had lower median household
Figure 3.

LISA Map OHCA Incidence and Socio-Economic Factors

Incomes ($14,375 to $45,288; Mesa median $50,079) than is typical for Mesa.

Alarmingly, residents of this cluster were relatively young. The median age for all block groups ranged from 28 years to 51.2 years, four block groups had a median age below the Mesa average (28 to 30.2 years; Mesa median 34.5 years).

Figure 4 shows the cluster of high-risk census block groups based on age and social isolation factors associated with incidence of OHCA. Areas in red indicate high values for both variables, while blue areas mean low values. There is a large 12-census block group cluster in east-central Mesa. Several of these block groups are in unincorporated Maricopa County and outside the MFMD response area. The remaining
Figure 4.

LISA Map OHCA Incidence and Age and Social Isolation

block groups within the cluster had a higher median age (45.3 years to 87.5 years; Mesa median 34.5 years) than the Mesa average, with five block groups having a median age 74.36%; Mesa median 25.7%) and elderly living alone (11.24% to 61.69%; Mesa median 9.95%) than is typical for Mesa.

Finally, an output of the PCA is a Z-score for each census block group and each component in the PCA. These scores were recorded based on the standard deviations to compute a standardized OHCA risk score for each census block group. The results are
Figure 5.

Predicted OHCA Risk by Census Block Group in the City of Mesa

Presented as a map in Figure 5. Very low-risk census block groups are white, while dark colors identify high-risk areas. This map essentially confirms the results of the analysis. High- and very-high risk census block groups are concentrated in low-income areas in west Mesa and elderly populations along Main Street and portions of east Mesa.

**Question 4. Are there public locations in Mesa with persistently high annual incidence of cardiac arrests per site that might benefit from a public access defibrillator program?**

Five years of cardiac arrest responses were abstracted from ePCR and Firehouse and cross-referenced with the MFMD Fire Prevention Bureau database to classify
locations based on the NFIRS public-use occupancy codes and descriptions. A total of 1,411 non-traumatic cardiac arrests occurred between January 1, 2007 and December 31, 2011. There were seven (7) location categories that each had a relatively high annual incidence of cardiac arrest, ≥.03 incidents per year per site, or one arrest per 30 sites in one year. These are listed in Table X. Of these, the highest number of arrests occurred in nursing homes (n=180), followed by hotels/motels (n=15), and residential board and care facilities (n=13). The annual incidence of OHCA per site was highest in hemodialysis centers (.30), residential board and care (.22), and nursing homes (.17). Most of the high-incidence locations were related to healthcare services of one type or another.

The literature identified several public-use occupancies that have high-incidence for OHCA events (e.g. airports, health clubs, etc.). Of these, only hotels/motels

Table 3.

<table>
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<tr>
<th>Location Category</th>
<th>Arrests in 5 years</th>
<th>Number of Sites</th>
<th>Annual Incidence Per site, Average</th>
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<tr>
<td>311 Nursing homes</td>
<td>180</td>
<td>216</td>
<td>.17</td>
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<tr>
<td>322 Substance abuse recovery center</td>
<td>5</td>
<td>22</td>
<td>.05</td>
</tr>
<tr>
<td>341 Clinic, clinic-type infirmary</td>
<td>5</td>
<td>12</td>
<td>.08</td>
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<tr>
<td>343 Hemodialysis</td>
<td>3</td>
<td>2</td>
<td>.30</td>
</tr>
<tr>
<td>300 Healthcare, detention</td>
<td>3</td>
<td>12</td>
<td>.05</td>
</tr>
<tr>
<td>449 Hotel/Motel</td>
<td>15</td>
<td>63</td>
<td>.05</td>
</tr>
<tr>
<td>459 Residential board &amp; care</td>
<td>13</td>
<td>12</td>
<td>.22</td>
</tr>
</tbody>
</table>
demonstrated higher-incidence in Mesa with 15 OHCA incidents occurring in 63
hotels/motels for an annual incidence per site of .05. Mesa’s two airports – Phoenix-
Mesa Gateway Airport and Falcon Field – had no reported cardiac arrest scene responses
to either the terminal or airport-operated facilities over the past 5 years. Clubhouses and
athletic clubs similarly reported few OHCA events, with annual incidence per site of .025
and .017 respectively. The remaining categories very few arrests annually. For example,
churches, elementary schools, and restaurants had an incidence of .002 per year, or 1
arrest per 500 sites, and office buildings had an incidence of <.001 per year, or 1 arrest
per 1,000 or more sites per year.

Discussion

This applied research project identified high-risk spatial clusters of OHCA at the
neighborhood level, indicating variable morbidity and mortality risk from SCA within the
city of Mesa. The current investigation suggests that health risks can be highly variable
within a community and therefore studies performed at the state or county level may not
be sufficient to accurately identify localized health disparities or supply actionable data to
local fire and medical departments. State and county health departments frequently
conduct analyses that supply information for planning and community initiatives. For
example, the State of Arizona has published The Burden of Cardiovascular Disease in
Arizona and the Cardiovascular Disease Plan to assist public health workers in
developing and coordinating approaches to cardiovascular disease prevention; and
Maricopa County has released the Health Status Report for Cities and Towns in
Maricopa County 2007-2009 and the Report on the Health Status of Older Adults in
Maricopa County, Arizona to help address county-wide preventable health problems.
Yet, neighborhood-level spatial disparities go undetected in such reports. For health and safety programs to be most effective, neighborhood-level demographics and specific needs must be considered.

The cluster findings of this study suggest that one of the best predictors of OHCA incidence in the city are the presence of social isolation factors in combination with older age. This is concerning given the aging of the Mesa population (Nelson, 2010). A significant increase in Mesa's elderly population will unquestionably strain the city's resources, especially for emergency medical care. Shifting demographics within the senior population will exacerbate this increased demand for municipal services. In general, as compared to the present elderly population, seniors in the Baby Boomer generation will have wider variability in formal education and wealth, fewer children, and a lower proportion of married households (Arizona Town Hall, 2003). These demographics can lead to social isolation and loneliness. “Loneliness shapes neighborhoods and is association with negative health outcomes” (Hall et al., 2010, p. 7).

One might conclude that the prevalence of master-planned senior communities in Mesa might mitigate some of the social isolation in senior populations. However, “some scholars have described limited social ties among resident of age-restricted communities. Furthermore, some research notes that in-migrants are reluctant to invest in relationships that are thought to be temporary” (p. 26). The policy issue for Mesa is how to best mobilize community resources to enhance the social resilience of seniors, promote healthy aging, and reduce preventable health problems that lead to premature sudden cardiac death.
High-incidence clusters were also found in low-income minority populations, though the results were mixed. The association between SES and health, particularly coronary heart disease, has been well established (Steptoe & Marmon, 2005). Interestingly, the independent variables of “poverty” and “not speaking English” were not statistically correlated to OHCA incidence, and only “not White” was. In the LISA analysis, however, poverty clusters with OHCA, but only in a few census block groups. Ultimately, the “immigrant” factor needs to be further refined before any conclusions can be made. To better refine this factor, an analysis might explore race (non-White), foreign-born population, industry (particularly agriculture, construction, “other service,” and unemployed), health insurance coverage (uninsured and/or public health insurance), percentage below the poverty level, and education (less than a high school diploma). The thinking here is that since immigrant populations tend to have lower educational attainment, are more likely to be employed as operators or laborers, and have higher rates of unemployment and families living below the poverty level (Sorlie, 2004), these components may prove to be a more coherent set of variables to measure health and safety challenges among immigrant populations.

This study demonstrates that the use of GIS, spatial statistics, and cluster detection methods can aid chief fire officers in identifying spatial disparities of risk within their communities. Further, it recognizes that neighborhood-level analyses can provide insight into how social conditions such as social isolation, poverty, disabilities, linguistic isolation, inadequate housing, and other factors influence health and safety incidence and outcomes in the population. From a community risk reduction perspective, the implication of these findings is that a neighborhood-level approach is necessary to
ensure that scarce resources and public outreach efforts are targeted to populations at greatest risk. Identification and management of major causes of premature death is essential for improving public health and safety, and understanding the causes of health disparities is critical to developing effective prevention programs.

Another important aspect of this applied research project was to determine the relative risk of public locations for incidence of cardiac arrests in order to plan for placement of public access AEDs. Past studies have identified various settings that have high incidence of OHCA including airports (Becker et al., 1998), casinos (Valenzuela et al., 2000), and fitness centers (Reed et al., 2006). However, others have had difficulty in identifying high-yield sites for locating public access AEDs (Cooper et al., 1998; Gratton et al., 1999). Unfortunately, the present research found a dearth of high-incidence public locations for OHCA in Mesa. Hemodialysis centers, residential board and care, and nursing homes had the highest incidence of OHCA in the city and present potential target of opportunity for AED placement. However, some of these facilities are regulated by the state or may have their own medical oversight. Further investigation into the regulatory framework of these facilities is necessary to determining whether Mesa has the legal authority to require AED placement. Furthermore, the literature noted that the prognosis of OHCA patients from nursing homes and extended-care facilities is poor (Portner et al., 2004; Gratton et al., 1999), with one study demonstrating no survival to hospital discharge (Awoke et al., 1992). Requiring placement in such facilities may not lead to an increase in Mesa's OHCA survival rates.

Finally, it was hoped that this research would identify clusters of high-incidence of OHCA and low-bystander CPR rates. Regrettably, only 30.6% of OHCA events were
witnessed (excluding events witnessed by EMS), and only 41 (of 304 with reported data) cardiac arrest patients received bystander CPR during the study period. Clearly, much work needs to be done citywide to improve bystander CPR rates in the city of Mesa.

**Recommendations**

Despite advances in pre-hospital cardiac arrest treatment and post-resuscitation management by the MFMD, the incidence of OHCA remains a major cause of premature death in the city. Improving survival of OHCA depends on identifying weak links in the AHA "chain of survival." The results of this study suggest that the weak link in the system is low rates of bystander CPR. “Bystander CPR is the most important contribution from the lay community to the OHCA system of care” (AHA, 2010, p. 2905). Spatial cluster analysis identified neighborhoods within the city that have a higher incidence of OHCA. PCA suggests that socially isolated older persons and immigrants living in poverty also experience higher incidence of OHCA, although more research is needed. These neighborhoods and populations present targets of opportunity to focus public health resources and MFMD prevention efforts.

Unfortunately, the results of the statistical analyses are not robust enough to support the adoption of an ordinance to mandate the implementation of a PAD program, which was being considered for introduction by the Mesa City Council. Therefore, the broad-ranging recommendations set down in this section are not suggestions for new policy mandates; rather, they are simply guides for where the most benefit could be gained from interventions. The strategies that are suggested recognize that individuals are responsible for their own behavior and should adapt positive lifestyle changes that improve health and reduce the risk of OHCA. However, it also recognizes the influence
outside forces such as schools, workplaces, and community organizations have on promoting and maintaining healthy lifestyles. Through collaboration and public-private partnerships, a larger impact can be made in reducing death and disability from SCA.

• **Collect, analyze and report data on OHCA incidence and outcomes.** Better data is needed to develop a cogent evidence-based strategy to reduce cardiac-related morbidity and mortality in Mesa. While current outcome data include ROSC at ED arrival, data on survival to hospital discharge are lacking. The MFMD EMS Division should establish a local registry for surveillance of OHCA in the city. The system should utilize Utstein style definitions and reporting templates. Data can then be used to compare process and outcomes in Mesa with those of other locations utilizing a uniform reporting template. Anonymized data can be shared with the Information Technology Department to track geographic “hotspots,” identify high-risk public locations, and track incidence and outcomes of at-risk populations over time.

• **Conduct a needs assessment of the needs of older adults in Mesa.** The preliminary results of this study identified social isolation factors that might be negatively associated with cardiac arrest incidence and mortality. The Mesa City Council should task the Human Services Division with establishing a Senior Advisory Committee to identify the needs of older adults. From this, a health enhancement strategy can be designed to support the management of chronic conditions that can lead to SCA, and put mechanisms in place to facilitate seniors’ work, service and social interaction opportunities.
• **Identify policies and programs to reduce health disparities.** Low-SES has been linked to cardiovascular disease and chronic conditions that may lead to SCA. This study found several low-SES neighborhoods with high incidence of OHCA. The MFMD, in cooperation with public health agencies, nonprofit entities, and private healthcare partners, should develop and support community-based outreach, health promotion and preventative healthcare efforts with special attention to low-income, minority, and migrant communities. Data from the local OHCA registry should be used to establish benchmarks for guiding program development and measuring program performance in reducing health disparities.

• **Increase CPR training and awareness.** Reported bystander CPR rates in Mesa are extremely low. Mesa should consider a working group to explore ways to increase CPR training and awareness programs. For example, the rapid proliferation of mobile personal communication technology such as smart phones offers a new platform to provide CPR training to a wider audience at low cost. Apps have been developed that can notify nearby CPR-trained Good Samaritans to major cardiac emergencies occurring in public places. This app might also be useful in adult master planned communities to notify security patrol volunteers. Other apps can pinpoint the location of the nearest public access defibrillator.

• **Consider AED placement in municipal buildings.** The City Council and City Manager should make AED placement a priority for all municipal departments and facilities in a PAD model. While municipal facilities did not appear to be high-risk locations for OHCA, placement of PAD-AEDs in city buildings provides leadership opportunity for the city and promotes public awareness of
SCA, AEDs and CPR. An RFP should be issued to procure AED devices, program management and training services.

- **Establish a trial for AEDs in police patrol vehicles.** The vast majority of cardiac arrests in Mesa occur in homes, where a PAD program would not influence survival rates. Mesa police officers currently receive initial CPR and AED training in the recruit academy followed by annual refresher training. However, patrol units are not equipped with AEDs. The MFMD should work with the Mesa Police Department on a trail of AEDs in patrol units, targeting patrol areas with the highest incidence of OHCA. Cardiac arrest should be made a Priority E call, indicating a life threatening incident with great possibility of death or serious injury.

- **Use GIS to identify and address other community hazards.** GIS offers a platform to identify and map fire and public health trends. Strategies and tactics can then be devised to target at-risk populations, solve problems, and improve the quality-of-life for Mesa residents and visitors. This process could be adapted into an organizational management tool similar to CompStat for police. Battalion chiefs would be required to tract incident trends and held accountable for reducing incidence of fire and preventable accidents in their districts.

The findings of this project, as well as its limitations and the challenges encountered in its execution, present opportunities for future research that continue to develop methods for investigating neighborhood-level public health and safety concerns. An ongoing challenge of this work was the lack of some data at the neighborhood level. For example, it has been well established that co-morbidities, such as obesity, diabetes,
and hypertension, are important determinants of cardiovascular health and survival of SCA. Other risk factors including personal behaviors (lack of physical activity, poor diet, tobacco use, alcohol consumption) the built environment (access to healthy food, proximity to a neighborhood park), and neighborhood conditions (crime rate, vacant properties) may be important contributors to health and safety disparities, but were not available at the census block level at the time this project was completed. Therefore, future research should consider including these variables to provide better evidence-based strategies.

This work might be considered a snapshot of the incidence of OHCA in Mesa, Arizona. Data from ePCR were available from October 2010 through March 2012. Less detailed data were abstracted from the Firehouse database to supplement the ePCR data to track incidence of OHCA over a 5-year period. However, city demographics change over time due to migration, gentrification of urban areas or urban sprawl, changes in economic conditions, and housing and social developments. Therefore, the MFMD needs to encourage temporal analyses so that they may adapt to changes over time and better support ongoing community health and safety planning.

In conclusion, this project identified important disparities in incidence of OHCA in several Mesa neighborhoods. Clusters of OHCA were found in neighborhoods where there is a presence of social isolation factors in combination with older age, as well as low-income minority populations. Public use occupancies that cater to seniors appear to be “at-risk” for incidence of cardiac arrest. These findings are important for guiding resource allocation, targeting prevention efforts, and informing policy decisions to support evidence-based public health and safety strategies to reduce these disparities and
reduce preventable mortality. Overall, this neighborhood-focused approach recognizes that risk reduction interventions must be tailored to suit the needs of the community so that they work effectively address the problems affecting specific population groups and, ultimately, improve the quality-of-life for all residents.
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