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Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Professional Firefighters on Crowdsourced Emergency Response in Metropolitan Cities

A Dissertation Submitted in partial fulfillment of the
Requirements for the degree
Doctor of Public Administration

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Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Professional Firefighters on Crowdsourced Emergency Response in Metropolitan Cities

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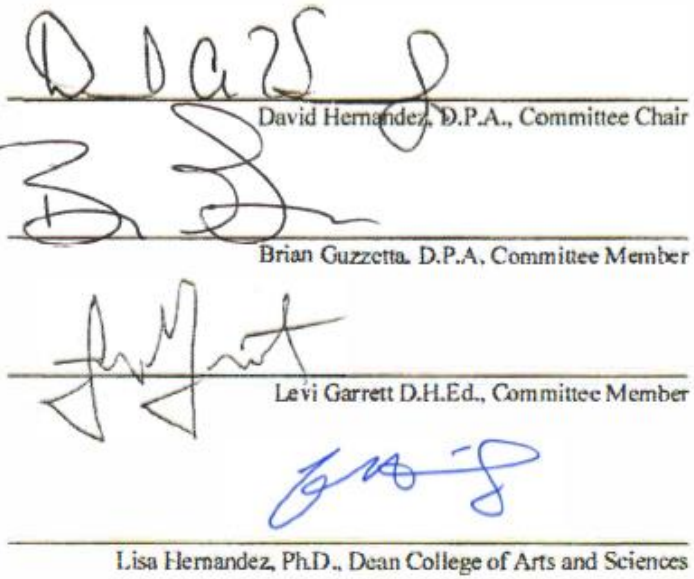

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ABSTRACT

The purpose of this study was to explore the perceptions of off-duty professional firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. The research focused specifically on the provision of lifesaving interventions to individuals experiencing sudden cardiac arrest in residential settings in metropolitan cities because the availability of public safety resources is typically fixed, and off-duty professional responders may be a viable solution to increase survival rates. The theoretical framework of the study was grounded in the foundational concepts of Pareto optimal/efficient allocation. The research aimed to identify whether leveraging off-duty trained responders could potentially address the issue of resource allocation in public safety. The research followed a qualitative case study methodology, focusing on sudden cardiac death in out-of-hospital settings. Semistructured virtual interviews were conducted with off-duty professional firefighters to understand their perceptions of the topic. The emergent themes provided insights into individual responses to sudden cardiac arrest, which enabled the identification of opportunities to help solve the problem. Two perspectives emerged from the research, namely an individual and an operational perspective. The individual perspective was refined into either a service focus or a safety focus, and the operational perspective was refined into a resource availability focus or a crowdsourced response technology focus. The predominant position was that off-duty professional firefighters are comfortable responding to sudden cardiac arrest in a residential setting in certain situations. However, the belief that they will universally respond to private settings when alerted is false. The study recommends that crowdsourced emergency response technologies continue to

evolve to meet the needs of the end user. Overall, the findings suggest that technology-based, crowdsourced solutions can have an impact by saving lives. The research contributes to the understanding of off-duty responders' perceptions and identifies potential opportunities for the development of crowdsourced emergency response technologies. This study provides a valuable contribution to the field of public safety resource allocation and emergency response planning.

Keywords: sudden cardiac arrest, residential setting, crowdsourced, crowdsourcing, firefighters, professional firefighters, off-duty response

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DEDICATION

I am filled with gratitude for the support and love that my family has provided me throughout my journey. It is because of their encouragement and inspiration that I have been able to pursue my passions and achieve my goals.

First and foremost, I would like to dedicate this document to my parents, Robert, and Sandra. They instilled in me the value of education from a young age and always encouraged me to pursue my dreams. Their encouragement and guidance have been instrumental in shaping who I am today, and I am forever grateful for all that they have done for me.

Next, I want to thank my wife, Kimberly, who has been my number one supporter and cheerleader throughout this journey. Her unwavering faith in me and constant reinforcement of "you got this" have kept me going even when the going got tough. I could not have done this without her love and support, and I am forever grateful for her impact and presence in my life.

Finally, I want to acknowledge my two beautiful children, Chase, and Sloane. They have been a constant source of inspiration and motivation for me. Their presence in my life has brought me immeasurable joy and purpose, and I dedicate this document to them with all my heart. I am incredibly grateful for my family. Without them, I would not be where I am today. Thank you for everything.

"For what will it profit a man if he gains the whole world, and loses his own soul?"

—Matthew 8:36

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CHAPTER 1: INTRODUCTION

Sudden cardiac death in the out-of-hospital setting remains a significant issue in the United States (Dicker et al., 2019). Many of these events occur in private residences and away from any help except for the 9-1-1 system. However, an opportunity may exist to save more human lives. In this context, saving a human life is defined as rendering lifesaving interventions, such as cardiopulmonary resuscitation (CPR) and automated external defibrillation (AED), to victims of sudden cardiac arrest outside of the traditional hospital setting. The opportunity concerns adding emergency response capacity through crowdsourcing technology.

Background

Sudden cardiac arrest is a severe medical emergency when the heart suddenly stops beating, often because of an electrical malfunction. It is a leading cause of death in the United States, with approximately 350,000 cases occurring annually (American Heart Association, n.d.-a; Benjamin et al., 2019). Most of these cases occur outside the hospital setting, such as in homes, public places, or workplaces, where emergency medical services may not be immediately available (Benjamin et al., 2019). The survival rate from out-of-hospital sudden cardiac arrest has remained low for several decades, remaining about 10% (Kitamura et al., 2018). The chances of survival decrease by 10% for every minute without CPR and defibrillation (Sasson et al., 2010). However, prompt and effective bystander CPR and early defibrillation with an AED can significantly improve survival rates.

The American Heart Association (n.d.-c) has recognized the importance of early intervention in sudden cardiac arrest and has implemented several initiatives to improve

outcomes. These include promoting public education on CPR and AED use, improving the quality of emergency medical services, and encouraging community-based interventions to increase access to AEDs. Despite these efforts, disparities in sudden cardiac arrest outcomes exist among certain groups (Sasson et al., 2013). Studies have found that survival rates are lower among racial and ethnic minorities, women, and those living in low-income areas (Mozaffarian et al., 2016). Some possible explanations for these disparities include differences in access to healthcare, lower rates of bystander CPR and AED use, and lower quality of emergency medical services in certain areas (Sasson et al., 2012).

Efforts to improve sudden cardiac arrest care and outcomes, including increased access to AEDs and CPR training, must continue. Addressing the disparities in sudden cardiac arrest outcomes requires a multifaceted approach, including increased public education and awareness, better healthcare access and quality, and community-based interventions targeting vulnerable populations (Mozaffarian et al., 2016).

Research Problem

The current emergency activation system is designed around the caller dialing 9-1-1 and requesting emergency medical services that are provided by the local fire department and private ambulance transporting agency. The ability to render immediate care for the cardiac arrest victim is with the trained bystander/resident.

The purpose of this study was to explore the perceptions of off-duty professional firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. This concept focused explicitly on rendering lifesaving interventions to individuals suffering sudden cardiac arrest in the residential

setting. The crowdsourced notification for off-duty firefighters to respond would occur through a cellular phone notification application (app). The desire to respond comes more from a strategic perspective, but the technology that tells off-duty firefighters to respond comes more from a tactical perspective. The availability of public safety resources is generally fixed, and leveraging off-duty trained responders could increase survival (Sasson et al., 2010). The present study captured an understanding of firefighters' perceptions of the topic through semistructured virtual interviews. From the interviews, themes emerged that created an enhanced understanding of end-user engagement and how it could potentially impact outcomes for a representative community.

Research Question

The research question that guided this study was as follows:

What are the perceptions of off-duty firefighters regarding crowdsourced emergency response technologies for victims of sudden cardiac arrest in the residential setting?

Significance of the Problem

The general problem that this study addressed is sudden cardiac death in out-of-hospital settings in the United States. The specific problem is that many of these out-of-hospital incidents occur in private residences or residential facilities. Currently, the only widely used lifesaving resources available to those suffering a sudden cardiac arrest in the home are the existing 9-1-1 emergency response system (i.e., fire and emergency medical services) as well as individuals living in the impacted residence who have been trained to render care. This study examined whether the current response resources can

be expanded by focusing on firefighters who have training and experience as emergency medical technicians (EMTs) or paramedics (PMs) and how they perceive off-duty response in the communities where they reside.

An opportunity may exist to increase the survival of those who suffer sudden cardiac arrest through crowdsourcing technologies focused on those willing to assist. One study indicated an overall willingness of individuals to engage at an organizational-structure level, but it did not investigate the personal perceptions of those queried (Blackwood et al., 2018). Therefore, the present study examined the perceptions of off-duty responders to analyze the opportunities and barriers to implementation.

Theoretical Framework

This study's theoretical framework comprised the foundational concepts of Pareto optimal allocation, a term often used synonymously with Pareto efficient allocation. These theories were developed by economist and sociologist Vilfredo Pareto. Pareto acknowledged that many solutions help some people while hurting others. Thus, an overarching desire is to find solutions outside of traditional practices that help some people without hurting anyone else.

The application of Pareto optimality/efficiency could impact the outcomes of out-of-hospital sudden cardiac arrests by increasing survivability through the addition of additional lifesaving resources in the form of off-duty firefighters. Government- and private sector-provided response resources have a spatial and temporal existence (Igarashi & Peters, 2019). Public safety resources are generally distributed based on travel times in a geographic area; additional resources are added if response times increase because of traffic, population, and incident volume changes. Specifically, this

research aimed to determine whether the premise of Pareto-optimal could be reached if resources are allocated so that that no alternative state would cause some people to be better off without making anyone worse off.

Definitions

This section provides definitions of all terms that are relevant to the study.

9-1-1 system. In the United States, 9-1-1 is a universal telephone number operating under local governance that routes calls to a system of call centers, ultimately resulting in the dispatch of emergency personnel (Wagner et al., 2019).

American Heart Association. Founded in 1924 by six cardiologists, this is the nation's oldest and largest voluntary organization dedicated to fighting heart disease and stroke (American Heart Association, n.d.-d).

Automatic external defibrillator. Automated external defibrillators (AEDs) are computerized devices that are reliable and simple to operate. They enable trained lay rescuers to perform defibrillation, which is a critical element in resuscitation efforts (van Alem et al., 2003).

Baby boomer. Individuals born between 1946 and 1964 are commonly referred to as baby boomers. The generational term can be used to identify the common traits and attributes of the group (Dimock, 2019).

California Public Records Act. The California Public Records Act is a series of laws intended to guarantee that the public has access to public records of governmental bodies in California (National Freedom of Information Coalition, n.d.).

Cardiac arrest. Cardiac arrest refers to the sudden stoppage of heart function, which can occur suddenly or following other symptoms. Without appropriate action, it is often fatal (American Heart Association, n.d.-a).

Cardiopulmonary resuscitation. CPR is a lifesaving technique that is useful in many emergencies, such as a heart attack or near drowning, when someone's breathing or heartbeat has stopped (Mayo Clinic Staff, n.d.).

Chain of survival. This term provides a useful metaphor for the elements of emergency cardiac care. The elements comprise early activation of the emergency response system (9-1-1), early CPR, and early AED. A strong chain of survival can improve cardiac arrest victims' chances of survival and recovery (American Heart Association, n.d.-e).

Crowdsourcing. Crowdsourcing embodies the concepts of cooperation, aggregation, and teamwork. It is an alternative method for doing work. Furthermore, it is a phenomenon by which, when the conditions are right, people can outperform individual experts, outsiders can bring fresh insights to problems, and geographically dispersed people can work together to produce alternative outcomes (Brabham, 2013).

Duty to act. Those who have a duty to act include healthcare workers and other emergency responders, which often applies even when they are off duty (Content Team, 2018).

Emergency medical services. The emergency medical services (EMS) are a system that provides emergency medical care. Once the system is activated by an incident that causes illness or injury, the focus of EMS is the emergency medical care of the patients (National Highway Safety Administration, n.d.).

Emergency medical technician. An EMT is an individual trained to render emergency care to the sick or injured in an out-of-hospital setting. EMTs are authorized to provide basic life support under the order of a physician or regional EMS authority (Pickrell, 2003).

Generation X. Generation X is a generational term generally applied to individuals born between 1965 and 1980. The term can be used to identify the common traits and attributes of the group (Dimock, 2019).

Generation Y. Generation Y is the generational term generally applied to individuals born between 1981 and 1996 (also known as millennials).

Generation Z. Individuals born between 1997 and 2012 are referred to as Generation Z.

Good Samaritan Law. The Good Samaritan Law is a law that protects civilians who help people they believe to be injured or otherwise in danger (Content Team, 2018).

Heimlich maneuver. This is an emergency medical procedure that is also referred to as an abdominal thrust. The procedure's focus is on clearing airway obstructions caused by foreign bodies (Rodriguez et al., 2022).

Mobile app. A mobile app refers to software designed for mobile devices like smartphones and tablet computers.

National Fire Protection Agency. The National Fire Protection Association (NFPA) is a global self-funded nonprofit organization established in 1896. It is devoted to eliminating death, injury, property, and economic loss because of fire, electrical, and related hazards.

NFPA 1710. NFPA 1710 is the standard for the organization and deployment of fire suppression, emergency medical, and special operations by career fire departments to the public. The standard provides the minimum requirements for resource deployment for fire suppression, EMS, and special operations while addressing firefighter occupational health and safety (NFPA, 2020).

Off-duty firefighter. This is an individual employed as a professional firefighter who is not physically at work and not being compensated.

Paramedic. A PM is an individual trained to render emergency care to the sick or injured in the out-of-hospital setting. They are authorized to provide advanced life support under the order of a physician or regional EMS authority (Pickrell, 2003).

Paretian criteria. This term is commonly used in economic literature and refers to the criteria of optimality and efficiency (Berthonnet & Delclite, 2015).

Pareto efficiency. Economist and sociologist Vilfredo Pareto founded this theory, which is often linked as a synonymous concept to Pareto optimality, the latter of which has become more commonly used since the 1970s (Berthonnet & Delclite, 2015).

Pareto optimality. Pareto also founded this theory. He acknowledged that many solutions help some people while hurting others. Thus, an overarching desire to obtain optimality is to find solutions that help some people without hurting anyone else (Mornati, 2013).

Prior to arrival. From a public safety emergency response perspective, prior to arrival refers to actions that have occurred before the arrival of 9-1-1 resources.

PulsePoint Respond. PulsePoint Respond is a mobile app in the United States that notifies citizens within 1/4 mile of a suspected cardiac arrest to facilitate resuscitation (Brooks et al., 2016).

Residential setting. This describes where individuals live; examples include single-family dwellings, condominiums, and apartments.

Sudden cardiac arrest. Sudden cardiac arrest is defined as an unexpected loss of the pulse without apparent extra-cardiac cause, occurring with a rapid collapse and specific resuscitation records available (Marijon et al., 2016).

ZIP code. U.S. Postal Service (USPS) ZIP codes are not physical geographic features but rather a group of mail delivery routes. These codes identify the individual post office associated with the mailing addresses of the identified mail delivery routes.

ZIP code tabulation area. ZIP code tabulation areas (ZCTAs) are generalized areal representations of USPS ZIP code service areas (U.S. Census Bureau, n.d.).

Disclosure

The researcher is a fire chief for a Southern California municipal fire department in the same regional environment where the study was conducted. The researcher is familiar with all the fire departments in the region. The researcher intentionally selected two cities to study that were neither where he is employed nor where he resides. Through decades of experience, the researcher may have interacted professionally with some of the study participants; however, neutrality was assured throughout the course of the research. This study's information, data, and conclusions were derived from the research process.

Organization

The remainder of this dissertation is organized as follows. Chapter 2 presents a review of the relevant literature, which is focused on the following topics: sudden cardiac arrest, Good Samaritan protection, crowdsourcing, crowdsourced cardiac arrest response, international crowdsourced cardiac arrest response, other emergency response crowdsourcing, Pareto optimality/efficiency, resource deployment, public good/fairness, and equity. Chapter 3 focuses on the research methodology and comprises the research design, population and sample, instrumentation, data collection, data analysis, and research limitations. Chapter 4 identifies data analysis, analysis of the interviews, identification of emergent themes, and a case study of two metropolitan cities. Last, Chapter 5 discusses the findings before presenting the conclusions, implications for action, recommendations for further research, and final reflections.

CHAPTER 2: REVIEW OF THE LITERATURE

This literature review chapter explores the intersection of topics related the sudden cardiac arrest, emergency response, and crowdsourcing. Specifically, it investigates the emerging field of crowdsourced cardiac arrest response and the potential benefits of this approach to optimizing resource deployment in the context of a public good. This chapter considers the role of Good Samaritan protection in enabling effective emergency response crowdsourcing and examines international correlations and other examples of emergency response crowdsourcing. The concept of Pareto efficiency/optimality is central to the discussions as are concerns related to fairness and equity in the allocation of resources. Overall, this chapter seeks to provide an overview of the literature on these interrelated topics, highlighting key findings.

History of the Subject Being Studied

To examine the history of crowdsourced emergency response technologies requires an approach that examines the core components. Such a method would examine sudden cardiac arrest outside of the hospital setting, the evolution of lifesaving actions, emergency response resource deployment concepts, and crowdsourcing technologies' early stages.

Sudden cardiac arrest in the out-of-hospital setting has been studied worldwide, and identifying the frequency of occurrence provides a starting point. Gräsner and Bossaert (2013) opined that "sudden cardiac death represents one of the greatest challenges facing modern medicine" (p. 293). This premise is true not only because of the volume of instances but also because of the associated social and economic impacts. In 2004, a large study found that in the United States, the incidence of occurrence is

55/100,000/year with a survival rate of merely 8.4% (Rea et al., 2004). Cardiac arrests in the out-of-hospital setting require purposeful intervention to increase survivability. Such interventions can be provided by trained rescuers or laypersons trained in lifesaving skills.

The lifesaving action commonly referred to as CPR first combined mouth-to-mouth breathing with chest compressions in the early 1960s (American Heart Association, n.d.-b). One of the first publicly focused CPR initiatives occurred in Seattle in 1969 when Dr. Leonard Cobb and Seattle Fire Chief Gordon Vickery initiated a program that asked, "Is it possible to save the lives of critically ill patients outside of a hospital?" (Medic One Foundation, n.d., para. 1). During the program's first 2 years, more than 100,000 people were trained in CPR (American Heart Association, n.d.-d). In the 1980s, the evolution of lifesaving interventions progressed to telephonic CPR instructions, followed by publicly available AEDs in the 1990s. Cheng et al. (2018) acknowledged that the effective use of human and material resources in low-resource environments is vital for achieving positive outcomes.

Emergency service resource deployment was a foundational aspect of the present study, and furthermore, the premise of limited good was also relevant. The focus of the resource deployment was on metropolitan areas and did not include rural communities because of the sparseness of available services. Time and distance are the factors that dictate emergency service resource deployment. Providers operate in a spatial environment because services are delivered to a specific location. Most emergency incidents become worse over time with diminishing survival rates; for this reason, emergency resource distribution and allocation are critical (Sasson et al., 2010; Neely &

Neal, 2002). The efficacy of public investments and services has been of civic interest for decades (P. C. Smith & Street, 2005). In the private sector, poor design often leads to higher prices, loss of competitiveness, and loss of business. However, inadequacy in service provision does not necessarily lead to immediate changes in the public sector because the need to evolve is not readily known (Church & Li, 2016). Researchers have proposed systems designed to mobilize citizen volunteers to assist the government (Lorenzi et al., 2013). This evolution could augment the fixed amount of government resources as well as create a more robust deployment model.

According to Estellés-Arolas and González-Ladrón-de-Guevara (2012), "The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills" (p. 198). The present study's application of crowdsourcing tied together the concept of sudden cardiac arrest, the skill sets required to manage the problem, resource allocation, and the exponential increase of those resources. Jeff Howe (as cited in Vander Schee, 2009), in his book *Crowdsourcing*, suggested that "the crowd will almost always outperform a set of employees given the right conditions" (p. 305).

Sudden Cardiac Arrest

In the out-of-hospital setting, sudden cardiac arrest is a leading cause of premature death, and bystander engagement can positively impact survival outcomes (Dicker et al., 2019; C. M. Smith et al., 2017; Sondergaard et al., 2019). For example, Dicker et al. (2019) found that early bystander CPR and public access defibrillation significantly increase survivability in out-of-hospital cardiac arrest. In addition, C. M. Smith et al. (2017) indicated that survival rates were nearly double when CPR and

defibrillation were used. Finally, researchers found that long-term outcomes improve with national programs focused on increased CPR rates (Sondergaard et al., 2019).

Understanding what drives those willing to render aid could improve positive outcomes and reduce fatalities (Piccinini & Schulz, 2019). Although Piccinini and Schulz (2019) explained a natural drive among relatives, some people have a secondary drive to aid those who are not closely related to them. These concepts are crucial for identifying the factors that drive bystander engagement. Furthermore, research has indicated that early bystander CPR regularly occurs in the out-of-hospital setting but not all the time (Dicker et al., 2019; Hansen et al., 2017; C. M. Smith et al., 2017; Tsao et al. 2022). In a narrative review of 64 articles, C. M. Smith et al. (2017) identified themes of public use defibrillation, which included the willingness to use and other behavioral factors. Their study revealed no single recommendation for enhancing AED adoption in public settings.

Further research by Hansen et al. (2017) indicated a positive increase in bystander engagement over 10 years, up from 1.2% to 15.3%, indicating that a substantial need for improvement remains. Finally, Dicker et al. (2019) suggested that socioeconomic factors further impact overall engagement numbers.

AED

Portable devices that deliver an electrical shock to the heart in cases of cardiac arrest are known as AEDs. These devices are designed to be used by nonmedical personnel, and they are increasingly found in public places such as airports, schools, and sports arenas. Being simple to operate, AEDs can greatly improve the chances of survival for someone experiencing sudden cardiac arrest (Red Cross, n.d.).

AEDs work by analyzing the heart's rhythm and determining whether a shock is needed. If a shock is needed, the AED delivers it through electrodes that are placed on the person's chest. AEDs are programmed to provide voice prompts to guide the rescuer through the process of using the device, and they also typically have visual aids such as diagrams or video displays to assist with placement of the electrodes. In addition, some AEDs are equipped with sensors that can detect the depth and rate of chest compressions during CPR, and they provide feedback to the rescuer on how to improve their technique (Red Cross, n.d.).

Additionally, AEDs have been shown to be effective in improving survival rates for sudden cardiac arrest. One study found that the use of AEDs by laypeople increased the survival rate from 4% to 40% (Weisfeldt et al., 2010). In addition, a meta-analysis of 18 studies found that the use of AEDs by trained responders resulted in a significantly higher rate of survival to hospital discharge compared to standard care (Hazinski et al., 2010). AEDs are now widely available in public places and are a vital component of the chain of survival for sudden cardiac arrest. They are designed to be used by nonmedical personnel and are increasingly found in public places such as airports, schools, and sports arenas. AEDs have been shown to be effective in improving survival rates for sudden cardiac arrest and are a vital component of the chain of survival. With their ease of use and increasing availability, AEDs have the potential to save many lives.

Good Samaritan Protection

Good Samaritan laws provide legal protection to individuals who help in emergency situations. In California, Good Samaritan laws apply to firefighters and paramedics (PMs) who provide emergency medical services (EMS) to individuals in

need. These laws are designed to encourage emergency responders to act quickly and provide necessary care without fear of legal repercussions. California's Good Samaritan laws for firefighters and PMs are outlined in the Health and Safety Code, which states that emergency responders cannot be held liable for damages resulting from their "good faith" efforts to provide medical care in emergency situations (Cal. Health and Safety Code § 1799.102).

The Good Samaritan laws in California also extend to individuals who aid emergency responders. For example, if a bystander assists a firefighter or paramedic in providing medical care, they cannot be held liable for any resulting damages, if they act in good faith and without expecting compensation (Cal. Health and Safety Code § 1799.102). Additionally, these laws apply to emergency responders who use an automated external defibrillator (AED) to save a life. If the emergency responder is properly trained to use the AED, they cannot be held liable for any resulting damages (Cal. Health and Safety Code § 1797.196).

However, emergency medical technicians (EMTs) and PMs can be held liable for gross negligence or willful misconduct (Cal. Health and Safety Code § 1799.110). Additionally, the California Emergency Medical Services Authority (EMSA) sets forth specific standards for the training, certification, and scope of practice of EMTs and PMs as well as requirements for reporting adverse events and incidents (California EMSA, n.d.). EMTs and PMs are required to adhere to ethical standards of conduct and professional behavior, as outlined in the National Association of Emergency Medical Technicians (2017) code of ethics.

Crowdsourcing

Jeff Howe first coined the term crowdsourcing in 2006 as a play on words based on the term "outsourcing" (Shepherd, 2012). Digout et al. (2013) further shared Howe's characterization of crowdsourcing as "the act of taking a job traditionally performed by a designated agent (Usually an employee) and outsourcing it to an unidentified, generally large group of people in the form of an open call" (p. 7). Schenk and Guittard (2011) further defined the word crowdsourcing as "a compound contraction of Crowd and Outsourcing" (p. 94). The implication is that crowdsourcing is another form of outsourcing or a way to reduce costs. However, the term has since evolved into something much more substantial; at a minimum, it is an innovative way to capitalize on the power of a group.

An early discussion on the topic identified organizational desires to leverage the productivity and knowledge of the crowd to replace or supplant available resources (Erickson et al., 2012). When large numbers of participants are recruited, the likelihood of finding a possible solution to the issue increases. Acquiring large numbers to build out any crowd increases the possibility of identifying the solution with the most significant possible impact (Schenk & Guittard, 2011). Another characterization provides that crowdsourcing is a participant-driven, problem solving, and creativity-driven process that creates solutions from an assembly of contributors (Zaamout et al., 2020).

Crowdsourcing empowers organizations that are facing a problem to significantly scale up a solution by leveraging technology (Brabham, 2013). Communities referred to as the crowd are often virtually invited to participate in tasks generally accomplished by

specialists (Shepherd, 2012). The source models primarily apply advanced technologies to operationalize virtual crowds to accomplish specific tasks (Saxton et al., 2013).

In *Crowdsourcing*, the concept of participatory culture was identified as a foundational principle that predates the term crowdsourcing (Brabham, 2013). Jenkins (2009) described participatory culture as

> a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices. A participatory culture is also one in which members believe their contributions matter and feel some degree of social connection with one another. (p. 15)

The concept of participatory culture has further correlations in consideration of the characteristics of the crowd. Crowd characteristics often include crowd knowledge, value, and location (Erickson et al., 2012). Crowd knowledge can be refined into general, situational, product or service, specialized, and domain expertise. Additionally, crowd value can be more closely examined by the crowd's diversity, distributed knowledge, and sheer size.

Some of the research concerning crowdsourcing has focused on matching the crowd with the need to meet the desired outcome. From a business model perspective, effectively matching crowd workers to suitable tasks is highly desirable because it enhances performance and improves the crowd workers' satisfaction (Hettiachchi et al., 2019). This premise is further supported by the intentional design of the crowd. One study categorized the crowd's efforts into four categories that identify the crowd as either

sensors, social computers, reporters, or micro taskers (Poblet et al., 2014). Although some believe that amateurs generally form the crowd, evidence suggests that such groups commonly comprise self-selected professionals and technical experts (Brabham, 2012).

Zheng et al. (2011) identified that both intrinsic and extrinsic motivations drive participation in crowdsourced endeavors. They found intrinsic motivations such as psychological, social, or emotional needs outweigh the extrinsic motivations of financial gain or individual recognition. This characterization aligns with the understanding that participants in crowdsourcing are often driven by individual capabilities, talents, and motivations (Brabham, 2013). On a broader scale, identifying whether the role is that of being the beneficiary or that of the crowd in the equation helps to define motivations.

Another aspect of crowdsourcing examines the adoption of crowdsourced technologies through the lens of generational cohorts. Calvo-Porral and Pesqueira-Sanchez (2020) found that Generation Y or millennials most frequently engage with cellular technologies for entertainment and hedonistic endeavors, but their Generation X predecessors are focused on more practical purposes. Another study identified three concepts that influence the adoption of crowdsourced mobile apps, namely usefulness, social influence, and hedonic motivation (Ali & Maideen, 2019). One emergent theme also identified perceived risk with app adoption, and the study ultimately found that Generation Y or millennials were more apt than Generation Z to adopt mobile crowdsourcing apps with higher perceived usefulness, social influence, and hedonic motivation.

Crowdsourced Cardiac Arrest Response

Cellular phone technologies have been developed that crowdsource citizen volunteers to nearby out-of-hospital cardiac arrests to initiate resuscitation before the arrival of emergency response resources. Valeriano et al. (2021) performed a scoping review to map the available literature on 25 crowdsourcing technologies and compared their technical specifications. The initial query was based on the keywords "mobile phone technology" AND "cardiac arrest" AND "out-of-hospital/bystanders." Studies have also been conducted internationally to evaluate the feasibility of crowdsourced technologies. In 2016, researchers in Stockholm, Sweden, were able to recruit over 23,000 lay responders through emails, advertisements on social media and in newspapers, and through CPR training companies (Berglund et al., 2018).

The most implemented platform in the United States is the crowdsourced mobile app PulsePoint. The early challenges faced by PulsePoint were centered on technical issues such as sound, excessive activations, and insufficient end-user density (Brooks et al., 2018). Researchers explored the willingness of fire-based EMS organizations from Washington State to respond with or without an AED to private-residence cardiac arrest outside of working hours using a smartphone platform (Blackwood et al., 2018). The researchers used a 5-point Likert scale to assess responses. Although this research indicated an overall willingness to engage at an organizational-structure level, it did not investigate the personal perceptions of those queried.

Recent studies have examined current crowdsourced programs. For example, Blackwood et al. (2020) examined the Verified Responder Program in the communities of Madison, Wisconsin; Sioux Falls, South Dakota; Spokane Valley, Washington; and

Tualatin Valley, Oregon. In these communities, off-duty emergency responders were equipped with AEDs. They were alerted using a geospatial smartphone app and could respond to nearby private and public locations in need of their assistance. The study evaluated the frequencies of verified responder notifications, response, scene arrival, and initial care before the arrival of emergency resources (Blackwood et al., 2020). The authors concluded that the response in private locations using off-duty EMS personnel is safe and has modest measurable public health benefits.

Moreover, a 2020 webinar by the International Association of Fire Chiefs examined how PulsePoint could expand community engagement by leveraging off-duty emergency response professionals. The webinar was hosted by fire service subject matter experts, medical professionals, and industry leaders who were well-versed in crowdsourced emergency response protocols. The introductory components of the app evolution were outlined by Price et al. (2020) as follows:

> PulsePoint Verified Responder Pro is the professional version of PulsePoint Respond, providing advanced functionality for agency personnel. Verified Responder extends PulsePoint CPR-needed alerts beyond public locations. PulsePoint offers Verified Responder for medically trained community members and Verified Responder Pro for public safety agency employees. These individuals are notified of ALL cardiac arrest events, including those in private homes. Agencies manage their Verified Responder program enrollment and invite employees and community members to participate. Verified Responders can be equipped with an AED, PPE, or any other equipment deemed valuable for use prior to the arrival of advanced care. (4:48)

During the Citizens CPR Virtual Summit, Price and Richard (2020) discussed the CoCreate workshop about program evolution with thought leaders from King County EMS, Rogers (AR) Fire Department, PulsePoint, and the Resuscitation Academy). The workshop asked the following questions:

1. What would inspire you to join the PulsePoint Verified Responder program?
2. What would inspire your family or friends to join the PulsePoint Verified Responder program?
3. Should an AED be with you all the time or available at the location where you go?
4. Why does every PulsePoint Verified Responder not have an AED?
5. What gaps do you see in the current PulsePoint Verified Responder program?
6. Who should own the AED, and what should be the payment model?

Two primary aspects related to response and equipment emerged. The response themes identified the need to build awareness, provide proper training, and ensure safety for the responders and others. The equipment themes focused on AED issues, such as access, maintenance, and cost (Price & Richard, 2020).

International Correlations

Crowdsourced emergency response programs are also in use outside of the United States. Examples of three international programs are the HeartSafe program in the United Kingdom, the Heartrunner Program in Denmark, and the Heartrunner Program in Sweden (Jonsson et al., 2020). All three programs dispatch lay responders via smartphone apps. Additionally, they provide the responders with information on the

location of nearby AEDs, which are critical for increasing survivability in out-of-hospital cardiac arrests.

Sweden has been a pioneer in crowdsourced sudden cardiac arrest notification procedures. Early research identified the benefits of a 500-m notification perimeter (Ringh et al., 2015). In one study, using smartphone platforms for locating and dispatching CPR-trained volunteers to provide care to cardiac arrest patients was found to significantly increase the rate of early bystander CPR (Ringh et al., 2015). Later research found that bystander CPR could be increased by 30% (Berglund et al., 2018). Another significant operational benefit is the Swedish AED register, which was first introduced in 2009 to identify AED in a geographic region. In 2016, there were 2,592 AEDs in Stockholm County, one AED/1,000 residents, or two and a half AED/km^2 (Berglund et al., 2017). Sweden is no different from most other countries where most out-of-hospital cardiac arrests occur in private homes; thus, increasing bystander-initiated resuscitation at home would yield an increase in lives saved (Andelius et al., 2022). If a family member is not physically or psychologically capable of performing CPR, volunteer responders can start CPR, bring an AED, and provide early defibrillation. Activating off-duty professional responders to private homes could be the first step toward volunteer responder activation. Recent research indicated that in Sweden, bystander defibrillation was more common in private homes with a volunteer responder than in public locations with a longer EMS response time (Andelius et al., 2022).

The Dutch Heart Foundation launched an out-of-hospital cardiac arrest research study that investigated time in relation to physical locations called “6-minute zones” (Zijlstra et al., 2014, p. 1444). The premise was to provide a response that achieves

defibrillation within the desired time frame. A text message was sent to one-third of the local lay responders within 1,000 m (.6 miles); the other two-thirds received a text message directing them to an AED within 500 m (.31 miles). The premise was that most cardiac arrests occur in residential settings that are not subject to public access AED programs; thus, the study was an attempt to combine the concepts (Zijlstra et al., 2014).

Furthermore, the European Sudden Cardiac Arrest network: towards Prevention, Education and Net Effective Treatments (ESCAPE-NET) sought to improve knowledge regarding the occurrence of sudden cardiac arrest and improve capacities to increase survival across 10 countries (Empana et al., 2017). The study used a data set of 85,790 sudden cardiac arrests from participating countries. The intentions of the research were focused on integration, prevention, and treatment. One specific objective was "to evaluate effects of novel technologies for sudden cardiac arrest treatment by utilizing smartphone applications for rapid deployment of lay rescuers and novel technological solutions" (Empana et al., 2017, p. 8).

In addition, a Danish study focused on a smartphone app-based responder system with a population of 819 citizen responders over 1 year (Andelius et al., 2020). The study concluded that citizen responders arrived before EMS resources 42% of the time. This early arrival and CPR are crucial components of the chain of survival. An additional point worth mentioning from this study relates to the psychological impact on the citizen first responders who arrived before EMS resources. Fewer than 2% reported severe psychological impacts following their response, but the study identified the need to create debriefing programs for volunteer responders.

Early discussions on the use of volunteer notification systems to optimally integrate laypersons into emergency response started in 2011 with the EMuRgency research project. With input from Germany, Belgium, and the Netherlands, the project's name was created from the two words "emergency" and "urgent" (Elsner et al. 2013). Any early barriers to implementation were identified. Although emergency dispatchers agreed on the utility of a volunteer notification system, they took issue with the extra work required with its use (Elsner et al. 2013). German researchers Stroop et al. (2020) found that simultaneously sending crowdsourced notifications to CPR-skilled volunteers and established EMS resources can reduce overall response times. Their study examined out-of-hospital cardiac arrest response in three categories, namely mobile notification-started CPR, bystander-started CPR, and EMS system-started CPR. Ultimately, when mobile-notified rescuers responded, they were the first to arrive one-third of the time, and CPR had already been initiated by a bystander (Stroop et al., 2020).

Other European counties with citizen responder programs include the Czech Republic, Ireland, Italy, Romania, Scotland, and Switzerland (Andelius et al., 2021). In Taipei, Taiwan, a system-wide initiative was launched to improve out-of-hospital cardiac arrest survival by optimizing the community chain of survival (Lin et al., 2022). This initiative leveraged the Global Resuscitation Alliance's recommendations and included the key component of building a culture of excellence and smart technology implementation. As a result, a smartphone app was designed for crowdsourced CPR (Lin et al., 2022).

Other Emergency Response Crowdsourcing

Crowdsourcing for other emergencies has been used in natural and man-made disaster responses. Crowdsourcing is gaining more attention in both industry and academia for exploring the effects of disaster relief (Han et al., 2019). Han et al. (2019) developed a model that examined how crowdsourcing can be used most effectively in disasters. The relief model considered the technological, behavioral, and responsive dimensions as components that lead to the provision of post-event relief. These identified dimensions, coupled with the physical location of the problem, result in a better response. Identification analysis of disasters is a complex endeavor that benefits from the innovation of crowdsourced technology and tools (Poblet et al., 2014). Table 1 shows the application of crowdsourcing roles in emergency management is enhanced by understanding the disaster management cycle response of preparedness, response, recovery, and mitigation.

Table 1

Crowdsourcing Correlations and Disaster Management

Disaster management cycle	Crowd as a sensor	Crowd as a social computer	Crowd as a reporter	Crowd as a microtasker
Preparedness	●			●
Response		●	●	●
Recovery		●	●	●
Mitigation	●	●	●	

Note. Adapted from "Crowdsourcing Tools for Disaster Management: A Review of Platforms and Methods," by M. Poblet, E. García-Cuesta, and P. Casanovas, P., 2014, in P. Casanovas, U. Pagallo, M. Palmirani, & G. Sartor (Eds.), *AI Approaches to the Complexity of Legal Systems, AICOL* 2013 International Workshops, AICOL-IV@ IVR, Belo Horizonte, Brazil, July 21–27, 2013, Springer (https://doi.org/10.1007/978-3-662-45960-7_19).

Senarath et al. (2020) further examined the premise of detecting emergency incidents using crowdsourced Waze data. Waze is a smartphone mapping app that uses user location information to identify traffic patterns and routing recommendations. Depending on the function that the Waze user fills, they could perform across all the disaster management cycles. The most robust evolution would be the ability to detect emergency incidents more rapidly than traditional reporting modalities.

Following the 7.0 magnitude earthquake in Haiti in 2010 and the 2011 Fukushima nuclear disaster, crowdsourced reporting of impact areas and ongoing emergencies was leveraged. In the hours immediately following the Haiti earthquake, 40,000 independent reports for 4,000 different incidents were provided by the general population (Yang et al., 2014). Even with enduring poverty, 85% of Haiti's population has access to a cell phone, thus creating a platform for crowdsourced reports to work (Riccardi, 2016).

During natural disasters, the impacted community's social media can be leveraged to provide nearly real-time damage updates. Yuan and Liu (2018) found that during Hurricane Matthew, there was a significant correlation between Twitter posts and storm damage. Similarly, other researchers identified a relationship between crowdsourced social media posts and disaster damage resulting from Typhoon Haiyan (Deng et al., 2016).

Because of the frequency of multicasualty incidents (MCIs) in Israel, a crowdsourced program called the LifeGuardian app was introduced to activate volunteer first responders. The target population focused on off-duty doctors, nurses, and PMs. The participants were also provided with MCI response equipment, including airways, bag-valve masks, bandages, and tourniquets (Jaffe et al., 2017).

Last, research from Lebanon found that crowdsourced communication can be beneficial in managing man-made disasters, such as terrorist attacks, because Lebanon is a country with a history of terrorist attacks (Baytiyeh, 2018). One of the prevalent themes that emerged was that by sending information on various communication platforms by text, images, video, and audio, the location and conditions in need of immediate help could be identified.

Pareto Efficiency/Optimality

Pareto optimality focuses on a society's well-being and indicates that no further system improvement can be made without worsening another situation. Pareto recognized how the impacts of subjective sentiments have consequences for society and found that optimality seeks maximum utility for and of society (Mornati, 2013). This concept is further explained as the maximum value for the individual members of society and the maximum usefulness for the entire society.

Numerous studies focused on Pareto optimality have sought benefits for the economy, society, and the environment. Some of these studies have addressed various topics, including water resources, communication networks, and commodities. The themes that emerged in a water resource study were related to the constraints of supply, demand, and quality and how they impacted the desire for the highest benefit (Hou et al., 2014). Furthermore, a communication network study included optimization and framework development insights to create a scalable method with no downsides (Iancu & Trichakis, 2014). Last, a commodity-centric study identified two-sided altruism as well as how it impacts finite agents and goods (Raut, 2004).

Much of Pareto optimality and efficiency is grounded in justice, welfare, and the public good. Correlations can be made between an individual's health, and mental well-being is tied to their available resources. In terms of well-being, Pareto efficiency may require a reduction in the inequality of material resources (Hansson, 2004). Gayer et al. (2014) added that Pareto efficiency requires the involved parties to operate under common beliefs to perceive an allocation to be dominant over another. According to Brownstein (1980), the reallocation of resources only maintains optimality if the reordering harms no one.

A counter position by Popa (2007) contended that much ambiguity exists in the ideas of Pareto efficiency and optimality in real-world qualitative contexts. He identified the ethical implications of ambiguity when defining allocations. This premise does not account for the fact that Pareto was both an economist and a sociologist, which would later align with real-world qualitative applications.

Resource Deployment

Fire and EMS resources are foundational to the safety of individuals, communities, and the built environment. Emergency service resource deployment has historically occurred in a spatial context (Yao et al., 2019). Decisions regarding where to place response resources include the known physical location and the known unknowns of unit availability (Simpson & Hancock, 2009). Simpson and Hancock (2009) sought to determine the essential nature of emergency response, how operational research can support emergency conditions, and what tools would best serve emergency response and conditions. Resources may include not only trained professional responders but also equipment such as AEDs.

In the United States, the NFPA sets recommended minimum response times for all emergencies and recognizes that the faster care is provided, the greater the likelihood of survival (NFPA, 2020). When fire departments provide emergency services, a first responder equipped with an AED will ideally respond in 4 minutes travel time or less. NFPA Standard 1710 identifies the organization and deployment of fire suppression operations, EMS, and special operations in career fire departments. The standard identifies the levels of EMS treatment as a first responder, basic life support, and advanced life support. The minimum staffing identified for emergency medical treatment for critical incidents is two PMs and two responders trained to the basic life support level (NFPA, 2020). These expectations are becoming increasingly difficult for agencies to meet when impacts such as traffic patterns, road conditions, weather, and population densities affect response times.

In addition, urban fire station placement is a multidimensional problem that includes nuances, such as the risk profile, population distribution, access to healthcare, and construction budgets (Yao et al., 2019). Resource deployment is a planning problem that involves predictive analytics and network performance evaluation (Huang et al., 2007). Service reliability, secondary to resource demands, is essential in emergency management. Physical facility location and specialized resource allocation are the benchmark for validating the distribution of services. Examining these data and patient outcomes identifies a need for alternative service delivery models that include expanded private/public partnerships and portions of the resident population.

Coupling these core concepts with the number of available resources and emergency incident volume adds to resource placement complexities. Incident call

volume is not only an impact for responding resources; its consequences are also felt in the first phase of resource deployment, namely in the 9-1-1 dispatch center. Dispatch-assisted CPR is a crucial first step in managing out-of-hospital cardiac arrests (Ko et al., 2018). When driven by emergency medical dispatch procedures, dispatch-assisted CPR can improve outcomes (Kim et al., 2020). However, such optimal outcomes can be impacted when the number of call takers and that of dispatchers do not meet demand needs.

Another topic relevant to resource deployment is centered on access to equipment, specifically AEDs. Using an AED, coupled with bystander-initiated CPR, can improve survival rates and neurological outcomes in the more than 350,000 out-of-hospital cardiac arrests that occur annually in the United States (Srinivasan, 2017). Notably, having an awareness of AED locations and an understanding of how to access the equipment is not always ideal. The rates of bystander defibrillation have also been linked to AED access and physical placement (Hansen et al., 2017). Additionally, these rates remain low in the residential setting because of less availability of the vital resource. Karlsson et al. (2020) further validated this: "Though rates of bystander defibrillation have improved in public locations, they have remained stagnant at around 1% in home cardiac arrests where approximately 75% of cardiac arrest occur" (p. S75). Karlsson et al. further explained that a possible solution was to implement a strategy in which lay responders only need to travel one way from the AED to the patient in need of defibrillation.

Another strategy for AED resource deployment focuses on high-rise buildings. Because of the design of buildings, a significant delay occurs from emergency notification to patient contact time. Chan (2017) proposed placing AEDs in building

elevators as opposed to the traditional lobby-based placement. This recommendation allows for more dynamic resource availability. In another study, Srinivasan et al. (2017) provided a hypothetical solution to AED placement. Community mailboxes are part of the infrastructure of U.S. postal systems and are easily accessible and recognizable. They also serve as a component of a vast logistics network. The study's findings indicated that mailboxes are dispersed across the city more equitably than current known AED locations. These mailboxes provide a convenient opportunity for strategically placing AEDs to increase overall AED availability (Srinivasan et al., 2017). Ideas such as these could assist in handling resource availability and demand needs.

Public Good/Fairness and Equity

Today, public administrators are tasked with the problematic responsibility of defining social equity and subsequently determining the optimal methods for measuring, quantifying, and acting on the findings (Wooldridge & Bilharz, 2017). In 1968, George Frederickson moved the theory of social equality forward as the recommended third pillar of public administration (Frederickson, 1990). From the public administration perspective, an argument may be raised that the government should provide distributed services and resources when overarching public good properties exist. Public administration strives to make the entire organization and its delivery of public services efficient or economical. However, the public is highly varied, and efficiency and economy will almost certainly benefit some more than others (Frederickson, 2015).

In the book *Justice as Fairness*, John Rawls (1985) contended that "institutions of constitutional democracy should be arranged if they are to specify and secure the basic rights and liberties of citizens and answer to the claims of democratic equality when

citizens are conceived as a free and equal person" (p. 227). As the idea of what encompasses equity and fairness evolves, it is vital to acknowledge the ever-growing list that includes ethnic demographics, socioeconomic class, gender, sexuality, safe schools, public transportation, health care, environmental threats, intergenerational concerns, and even human trafficking (Guy & McCandless, 2012).

By examining equity and fairness more granularly through the context of emergency response resource delivery, the specific dimensions of the equity of public resource use and social exclusion can be measured. A 2017 public transportation study identified critical demographic data sets, which included age, ethnicity, household size, employment status, income, education, gender, vehicle availability, possession of a driver's license, and spoken language (CJI Research Corporation, 2017). These demographic data sets could be applied to research on the equity and fairness of publicly funded emergency response resources.

In another study, El-Geneidy et al. (2016) evaluated equity in fairness through accessibility, including social vulnerability indicators and social disadvantage. Their study bridged the gap between equity and fairness and drew correlations to increasing equitable access by closely examining operational efficiencies. Although the concept of social equity and fairness has evolved to include policymaking, its roots remain focused on organizations' fairness and the delivery of public services (Guy & McCandless, 2012).

Furthermore, a study that examined 9,235 sudden cardiac arrests in seven metropolitan cities in the United States and Canada found much higher numbers of incidents of sudden cardiac arrest in lower socioeconomic neighborhoods (Reinier, 2011). This identified an equity issue that needed a solution. It was determined that targeted

CPR training in these low-income communities with a higher incidence of sudden cardiac arrest was an action that could provide an impact. A similar study in New Zealand found a relationship between socioeconomics, out of the hospital cardiac arrests, and access to material resources such as public access defibrillators and CPR-trained bystanders (Dicker et al., 2019). Like the previous study, the solution was to provide targeted CPR training in the poorest neighborhoods and assess the distribution of AEDs. In turn, the focus would be the targeted distribution of AEDs in communities with noted scarcity.

Summary

In summary, this literature review chapter has provided a comprehensive overview of the topics related to sudden cardiac arrest, crowdsourcing, and emergency response. The chapter explored the emerging field of crowdsourced cardiac arrest response, considering the potential benefits of this approach for optimizing resource deployment in the context of public goods. The role of Good Samaritan protect was also examined, highlighting the importance of legal frameworks in enabling effective emergency response crowdsourcing. International correlations and other examples of emergency response crowdsourcing, as well as the concept of Pareto efficiency/optimality in resource allocation decisions, were discussed. The insights gleaned from this literature review serves as the foundation for the subsequent chapter on methodology, which outlines the research design and data collection methods used to investigate crowdsourced cardiac arrest response.

CHAPTER 3: METHODOLOGY

The purpose of this chapter is to provide a detailed description of the chosen research methodology for this study. The selected research methodology was the qualitative case study method. This chapter provides an overview of the research purpose, research question, research design, population, sample, instrumentation, data collection procedure, data analysis process, and research limitations. The qualitative case study method was chosen because it enables an in-depth exploration of the research topic and provides a comprehensive understanding of the experiences and perspectives of the participants. The following sections discuss each aspect of the research methodology in detail, outlining the rationale for each decision made. The final section of this chapter provides a summary of the methodology used in this study.

Purpose Statement

The purpose of this study was to explore the perceptions of off-duty professional firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. The concept focused explicitly on rendering lifesaving interventions to individuals suffering sudden cardiac arrest in the residential setting. Crowdsourced notifications for off-duty firefighters to respond would occur through a smartphone notification app. The desire to respond comes more from a strategic perspective, and the technology that tells the off-duty firefighter to respond arises more from a tactical standpoint. The availability of public safety resources is generally fixed, and leveraging off-duty trained responders could increase survivability. An understanding of firefighters' perceptions on the topic was captured through semistructured virtual interviews. From the interviews, themes emerged to create an

enhanced understanding of end-user engagement and how that could potentially impact outcomes for a representative community.

Research Question

To recap, the research question that guided this study was as follows:

What are the perceptions of off-duty firefighters regarding crowdsourced emergency response technologies for victims of sudden cardiac arrest in the residential setting?

Research Design

This qualitative case study focused on sudden cardiac death in out-of-hospital settings. Currently, the only lifesaving resources available to those who suffer a sudden cardiac arrest at home are the existing 9-1-1 emergency response system and individuals living in the impacted residences who have been trained to render care. Through developing emergent themes that provide insights into individual responses to sudden cardiac arrest, this study sought to identify opportunities to help solve the problem. Furthermore, this qualitative case study aimed to identify the perceptions that lead to Pareto optimal/efficient resource deployment. Naderifar et al. (2017) shared that qualitative research is designed to identify a deep understanding of a phenomenon rather than a generalization. This study focused on firefighters with EMS training and experience as EMTs or PMs and how they perceive off-duty response in their communities.

Semistructured interviews were used as the data collection instruments in this qualitative research study. The semistructured interview questions were designed to capture individual perceptions. Although professional culture may impact individual

perspectives, the focus was on identifying themes consistently and systematically (Qu & Dumay, 2011). Each interview question was framed to support the research question. Interview quality was maintained by establishing a positive relationship with the interviewee, thus allowing their story to flow and avoiding interviewer bias (Schensul et al., 1999). The interviews were conducted in a virtual environment using the Zoom videoconferencing app. Informed consent documentation was acquired from all participants before the interview. The participants were de-identified through an alphanumeric coding process that also maintains confidentiality for their representative fire departments.

The case study analysis added additional outcomes outside of the single sample group of off-duty firefighters. The case study approach creates the opportunity to provide context through simple to complex relationships found in communities, relationships, or programs (Yin, 2009). Additionally, case studies are usually considered a qualitative method. However, some aspects of case study research may include foundational quantitative information (Elman et al., 2016).

In the case study, cardiac arrest data from two cities were included. The boundaries of the two cities helped to prevent the research being too broad (Stake, 1995). Similarities and contradictions in annual cardiac arrest data resulted, and it was of interest from a research perspective how internal or external factors impacted the variable results. The decision to select specific cities was driven by a need to acquire detailed cardiac arrest information for the research. Choosing specific fire agencies instead of cities could have impacted the study because of organizational cultures. For example, if the culture of an organization values conformity and discourages inquiry, it may hinder the

generation of new ideas and limit the scope of the research. Conversely, an organization that encourages innovation and values diverse perspectives may lead to more insightful and creative research outcomes (Cameron & Quinn, 2011).

A comparative analysis of the off-duty professional firefighters from the two cities added depth to the overall research. Yin (2009) explained that one should seek to evaluate contextual conditions because one believes them to be relevant to the phenomenon being studied. By querying the identified sample group regarding their perspectives on crowdsourced lifesaving technologies, reoccurring engagement themes emerged to indicate the utility of the technology as well as areas for evolution.

Population

The population was centered on off-duty professional firefighters with training and experience as EMTs or PMs and how they perceive off-duty response in their residential communities. Off-duty professional firefighters who live in the Southern California metropolitan cities of Riverside and Anaheim were the focus. Multiple different fire agencies employ the firefighters who reside in these two cities. The cities have several baseline similarities that create a basis for comparison: First, Riverside has a population of 314,998, and Anaheim has 346,824 (U.S. Census Bureau, 2020); second, out of the 482 incorporated cities in California, Anaheim is the 10th most populated, and Riverside is the 12th most populated (U.S. Census Bureau, 2019); third, both cities have their own municipal fire departments that respond to over 30,000 emergency incidents annually; and fourth, both cities have an assortment of residential, business, industrial, and mixed-use zoning.

Sample

This phenomenological inquiry used a semistructured interview instrument to explore the perceptions of off-duty professional firefighters. Qualitative studies are not bound to quantitative statistical analysis methods, allowing the researcher to employ creativity in sampling (Ishak & Abu Bakar, 2014). A nonprobability design was chosen for the sample because of the specificity of the profession identified. Purposive sampling was selected because the characteristics of the sample group focused on those trained to deliver CPR as a component of their regularly occurring professional duties. Although Vogt and Johnson (2015) opined that purposive sampling is generally an unwise procedure because it makes assumptions and may introduce biases, it was necessary for the present study. This is because the present researcher addressed areas in which expectation bias could impact the legitimacy of the purposive sample.

Based on the ability to acquire an acceptable sample size, the study considered snowball sampling because of the specificity of the sample group. A snowball sample allows for additional purposeful samples to be added if saturation is not attained (Naderifar et al., 2017). Prior to formalizing the case study cities, the researcher determined that there was a sufficient sample size to meet the needs of the study. The 2019 U.S. Census Bureau American Community Survey focused on numerous occupation types, which were grouped and subcategorized. The group that included firefighters, prevention, and other protective services workers in the service occupations section was most applicable. This grouping comprises more than just firefighters, but it indicated a viable sample pool for the present inquiry. Anaheim and Riverside have 2,621 and 1,161 residents who fall within this occupation category, respectively (U.S.

Census Bureau, 2019). Given the number of firefighters residing in the designated research area, it was assumed that a viable sample would be achieved relatively quickly. The inclusion criteria were as follows: participants were required to be aged older than 18 years, to be paid professional firefighters, to possess EMS training as an EMT or PM, and to live in Anaheim or Riverside.

The researcher initially planned on creating a sample of 40 off-duty professional firefighters, 20 from each of the represented metropolitan cities. This starting point was based on researcher preference not any preidentified reason. Creswell and Poth (2016) indicated a common method for assessing sample saturation is to use theoretical saturation, which is defined as the point at which no new themes or categories emerge from the data. Once the previously identified sample size of 40 interviews was met, an additional 10% (n = 4) was added. No additional new insights or information resulted from the added interviews, and the researcher determined that sample saturation had been met. Though saturation was eventually met, the time to reach saturation had to be extended several times.

The researcher specifically recruited the candidates from department email lists solicited from regional fire departments. The fire chiefs from 14 regional fire departments in Southern California were contacted by email to solicit voluntary participation by their personnel. Several of the departments had no personnel living in Anaheim or Riverside. The chiefs messaged the researcher in various ways: some directly provided a list of email addresses for their staff who met the residence requirements; some forwarded the researcher's correspondence to their entire

departments; and others had their respective human resource department process the request and sent the interested individuals information about the research.

The final sample of 44 interviewees comprised 22 in Anaheim and 22 in Riverside. The sample of 44 was made up of seven different Southern California fire departments from three counties, as presented in Table 2.

Table 2

Fire Departments and Firefighters Interviewed

Fire department	Firefighters interviewed (n = 44)
Department 1 (D1)	3
Department 2 (D2)	7
Department 3 (D3)	7
Department 4 (D4)	9
Department 5 (D5)	2
Department 6 (D6)	15
Department 7 (D7)	1

The interviewees ranged in age from 28 to 62 years old and possessed 1 to 35 years of experience. The skill set was either that of an EMT or PM, and the individual ranks ranged from firefighter to deputy chief. Last, the sample group had lived in their respective cities for 1 to 51 years.

After gaining some voluntary participation, snowball sampling was leveraged to recruit additional participants. After the first round of interviews, the researcher asked the participants whether they knew of other firefighters in their community with whom they could share the research project. The snowball technique yielded eight additional participants who were known to the original interviewees. Once the repetition of stories

began to occur and no new information was emerging, saturation was determined to have been met.

To provide anonymity and ensure participants' privacy, their names were not identified. The researcher created an alphanumeric code that included the city of residence (ANA or RIV), the represented fire department (D1–D7), the firefighter interview number (FF1–FF22), and the firefighter skill set (EMT or PM). For example, an Anaheim resident working for fire department 1, who was Interview Number 1 and a PM, would be coded ANA-D1-FF1-PM. There were 44 different codes—one for each person interviewed.

Two raffle prizes with a value of $500 each were offered to elicit interest and participation. A random drawing by a neutral party was conducted using the 44 participant codes. The raffle prize for Riverside was awarded to RIV-D2-FF18-PM, and that for Anaheim was awarded to ANA-D4-FF9-EMT. As indicated in the informed consent form, $220 was donated to the Firefighter Cancer Support Network on behalf of the 44 participants.

Instrumentation

A virtual interview with semistructured questions allowed the respondents to answer uniquely. This approach also allowed respondents to say precisely how they felt about the topic instead of providing a list of predetermined responses for them to select from. The resulting exploratory data revealed unforeseen opportunities, issues, or correlations. Furthermore, employing qualitative interviews in a virtual setting created the opportunity to query a larger group of people, adding credibility and ultimately value to the study. The researcher developed the questionnaire specifically for this study. Each question sought to obtain additional information to add to the overall results. Although

the interview protocol contained only seven questions, the researcher also asked unstructured and inquisitive questions, such as “please expand more on that topic” to understand the subject better. Before each interview started, the researcher reminded the interviewee that they could stop the interview at any time and bypass any question if they felt uncomfortable about answering it.

The semistructured interviews included the following questions:

1. Explain your experience with applying your professional skills outside of the workplace.
2. What factors would make you want to render cardiopulmonary resuscitation voluntarily when off duty?
3. Your primary profession is centered on helping others; what conditions would preclude you from doing the same when off duty?
4. Tell me about the positive and negative experiences you have had with crowdsourced lifesaving technologies.
5. What aspects of your firefighting profession might influence your adoption of crowdsourced lifesaving technologies?
6. How does the physical location of an off-duty cardiac arrest impact your willingness to help? For example, is there a difference between a public and a private setting?
7. How could incentives impact your willingness to engage or not engage in off-duty response?

In addition, seven demographic questions were asked to help identify the characteristics of the Anaheim group, the Riverside group, and the collective group of off-duty professional firefighters living in the identified metropolitan cities.

The supporting demographic questions were as follows:

1. What is your gender?
2. What is your age?
3. What is your skill set?
4. What is your rank within your agency?
5. How long have you been a firefighter?
6. How long have you lived in the city?
7. What is your ZIP code?

Data Collection

Documents and processes were established to maintain the highest ethical and moral standards of research that included signed informed consent forms and the provision of interview protocols Because of the metropolitan city centric focus of the case study, an outreach correspondence was sent by email to the fire chiefs of city of Riverside and the city of Anaheim advising them of a research study that was planned to occur in their cities. In an individual follow-up phone conversation with both individuals, the details of the research were further discussed. Both chiefs were advised that the study could include members of their departments living in their respective cities and that personally identifiable information about any of their staff or fire department would be redacted to maintain anonymity. They were also advised that a public records request would be filed to query cardiac arrest data from their records management

systems for 2017–2020. The Anaheim chief signed a research agreement (see Appendix A) on May 20, 2022, as did the Riverside chief (see Appendix B) on May 17, 2022.

Furthermore, the fire chiefs from 14 regional fire departments in Southern California were contacted by email to solicit voluntary participation by their personnel. Several of the departments had no personnel living in Anaheim or Riverside. The chiefs messaged the researcher in various ways: Some directly provided a list of email addresses for their staff who met the residence requirements; some forwarded the researcher's correspondence to their entire departments; and others had their respective human resource department process the request and send their off-duty professional firefighters who reside in the target cities information about the research. Specifically recruiting the candidates from fire department email lists solicited the best response.

Next, a formalized recruitment process that included recruitment letters was delivered to the target sample group by email. The researcher used an authorized California Baptist University student email account for the recruitment. Following a responsive email, those willing to participate in the research received informed consent forms (see Appendix C) and the interview protocol, questions, and script (see Appendix D). The consent forms were saved in the Adobe PDF format and are accessible to the researcher until the established destruction date of January 1, 2028. Additionally, a coding process was structured to ensure that the identities of those involved remained confidential and protected. The goal of the process was to open and close quickly and not linger. The data collection process was initially open for 30 days and extended for an additional 2 weeks to capture a sufficiently large sample for the research.

After initial consent was secured, communication regarding interview scheduling was provided. A follow-up email was sent that provided access to the online scheduling website Calendly.com. The researcher provided interview availability in 30-min time intervals. The participants chose the time frame that best met their schedule. The first interview was scheduled for June 10, 2022, and the last was completed on July 25, 2022. The interview length varied, and the shortest interview was 19:54 and the longest was 38:58. The participants were informed that any questions they were uncomfortable answering could be skipped.

The interviews were conducted using Zoom, and the use of the web camera was left to the participant's preference. Using an established and recognized platform helped with participant familiarity and assisted with the timeliness of the inquiry. Because the video component was optional, the videos were not recorded. Some participants opted to be virtually interviewed off duty while at home. By contrast, others chose to be virtually interviewed while on duty. For those who were interviewed on duty, only one had to leave the interview for an emergency response. The remainder of the interview was completed when he returned to the fire station. An audio recording was captured using the smartphone app Rev Voice Recorder (https://www.rev.com/lp/home-2). The audio recordings were transcribed for later use in the data analysis process. The audio files were downloaded and will be deleted along with the consent forms on January 1, 2028.There were no foreseeable risks to the participants from the interviewees, and no deception techniques were used during the study.

Data Analysis

The information gathered from the interview questions was coded with the MAXQDA qualitative data analysis software package (https://www.maxqda.com/). MAXQDA supported the data's organization, allowing the researcher to generate insights from the interview process methodically by coding and statistical analysis. The objective was to have the software identify both basic and complex themes that emerged from the interviews. The codification of the information focused on keywords and phrases throughout all 44 interviews. Key statements and positions of particular interest were also explicitly tracked in the analysis process regardless of the frequency of occurrence. A total of 2,664 interview data points were included in the coded document system. The coding frequency ranged from 45 to 67 inputs for each of the firefighters interviewed. These words and phrases were compared individually, as a representative grouping from each city, and wholistically as an aggregate.

The secondary data focused on cardiac arrest data reports requested from the city of Anaheim and city of Riverside Fire Departments and were intended to provide community context for the two cities. Using the public record request process under the California Public Records Act, 5 years of cardiac arrest data (2017–2021) were requested from both agencies. Adherence to all associated public record request requirements was followed by the researcher. The cardiac arrest data were received from both agencies as Microsoft Excel spreadsheet files. Staying in alignment with the qualitative interview data, the information acquired from the public records request was uploaded to MAXQDA for further evaluation.

Limitations

Although this study aimed to explore off-duty emergency response behaviors among professional firefighters, several limitations were encountered throughout the research process.

The most significant limitation of the study was accessing and recruiting professional firefighters willing to be interviewed about their off-duty emergency response experiences. The initial outreach via email communication with fire chiefs was met with resistance from some leaders who perceived the request as an invasion of privacy for their employees. This resistance, along with the added communication requirement of consulting with human resources, created barriers to recruitment.

The second limitation was the incongruent data sets among fire department record management systems, which made exact linear comparisons difficult. However, enough of the information was consistent among the data sets that remained relevant in the case study. Despite these limitations, the study aimed to provide valuable qualitative feedback from the participants, which was the central focus of the research.

The most significant limitation of the study was the low willingness of the target audience to engage and participate, resulting in low return rates. In overcoming the anticipated recruitment issues, a monetary incentive was offered to those who agreed to be part of the study. Offering the chance to win a valuable prize is a commonly used incentive, as is a donation to charity as an intrinsic motivating factor (Kang, 2016). Two raffle prizes with a $500 value each were available to elicit interest and participation; one prize was available for Riverside respondents, and the other was for Anaheim

respondents. Additionally, the researcher donated $5 to the Firefighter Cancer Support Network for each participant.

It is possible that the off-duty professional firefighters decided on participation solely on the researcher's professional title of fire chief. Even though the researcher did not explicitly mention his title during recruitment outreach, many participants were aware. Some of those interviewed indicated this influenced their decisions to participate or not.

Overall, these limitations in this study highlight the challenges and complexities of conducting research in real-world settings. Nonetheless, the research provides valuable insights into the off-duty emergency response behaviors of professional firefighters and highlights the need for further research in this area.

Summary

This chapter outlined the research methodology used in this study, which was the qualitative case study method. It provided a detailed overview of the research purpose, research question, research design, population, sample, instrumentation, data collection procedure, data analysis process, and research limitations. By using this methodology, the researcher aimed to gain an in-depth understanding of the experiences and perspectives of off duty professional firefighters who are EMTS or PMs living in two southern California metropolitan cities. However, the study also had limitations, including challenges with organizational access to firefighters and differences in record management systems. Despite these limitations, the researcher was able to conduct a comprehensive and rigorous study. The next chapter presents the research findings,

derived from the data collected and analyzed using the methodology outlined in this chapter.

CHAPTER 4: FINDINGS

This chapter presents the findings from the interviews with professional firefighters, which were conducted following an expedited research approval by the Institution Review Board of California Baptist University. The data points are analyzed, and themes related to off-duty professional firefighters' emergency response to cardiac arrest victims are identified. Direct feedback from the interviewees is presented throughout the chapter to add clarity to the findings. This chapter also presents the additional research component of a case study of two similar metropolitan cities – namely Anaheim and Riverside. The case study first examines the results from the interview participants, all of whom are off-duty professional firefighters who lived in Anaheim and Riverside. The case study then synthesizes the results from the cardiac arrest information for the cities independently. Evidence regarding the interviews illustrated a direct causal relationship between the off-duty professional firefighters and their inclination to provide bystander CPR for cardiac arrest victims.

Purpose Statement

The current emergency activation system is designed around the caller dialing 9-1-1 and requesting emergency medical services that are provided by the local fire department and private ambulance transporting agency. The ability to render immediate care for the cardiac arrest victim is with the trained bystander/resident.

The purpose of this study was to explore the perceptions of off-duty professional firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. This concept focused explicitly on rendering lifesaving interventions to individuals suffering sudden cardiac arrest in the residential

setting. The crowdsourced notification for off-duty firefighters to respond would occur through a cellular phone notification application (app). The desire to respond comes more from a strategic perspective, and the technology that tells off-duty firefighters to respond comes more from a tactical perspective. The availability of public safety resources is generally fixed, and leveraging off-duty trained responders could increase survival (Sasson et al., 2010). The present study captured an understanding of firefighters' perceptions of the topic through semistructured virtual interviews. Evidence regarding the interviews illustrated a direct causal relationship between the off-duty professional firefighters and their inclination to provide bystander CPR for cardiac arrest victims.

Research Question

The research question that guided this study was as follows:

What are the perceptions of off-duty firefighters regarding crowdsourced emergency response technologies for victims of sudden cardiac arrest in the residential setting?

Research Methods and Data Collection Summary

The population studied consisted of off-duty professional firefighters living in the Southern California metropolitan cities of Anaheim and Riverside. These cities were chosen because they have similar populations, similar emergency incident volumes, and a similar mix of zoning types. The final sample included 44 interviewees with 22 living in each of the two metropolitan cities. The participants represented seven different fire departments in Southern California. The participants ranged in age from 28 to 62 years old with 1 to 35 years of experience, and they held various ranks from firefighter to

deputy chief. When the purposive sample slowed in participation, snowball sampling was used to gather additional participants.

Qualitative interviews were conducted via Zoom with 44 participants over 6 weeks. The interviews varied in length and occurred both on duty and off duty based on participant preference. The interviews consisted of seven demographic and seven semistructured questions, and participants had the option to skip any questions if they were uncomfortable responding. Before the interviews, participants reviewed and digitally signed an informed consent form, and the interviews were audio recorded and transcribed using artificial intelligence (AI)-powered transcription. AI-powered audio-to-text transcription enables the rapid and accurate conversion of spoken language into written text. The transcriptions were edited for accuracy, and analytic software was used for coding, focusing on keywords and phrases. The goal was to identify both basic and complex themes that emerged. The application of a defined coding system produced consistency in the analysis process.

Demographics of the Sample

Demographic questions were added to create a baseline for the sample group. The aim was to identify similarities and differences and to determine whether correlations existed in the responses. Some of the demographic questions related to residency applied to the case study of the two cities and how the respondents aligned with specific population demographics. The postal ZIP code of where the participants lived is also relevant later in this chapter when examining cardiac arrest data specific to the cities of Anaheim and Riverside because it is captured in their respective record management systems. All personally identifiable information, including specific addresses, was

removed from the cardiac arrest information. The cumulative demographic characteristics of the interviewees can be found in Appendices E and F.

Gender

All (n = 44) of the research participants identified as male. This demographic finding occurred by default, not by design because no female firefighters volunteered to participate during the recruitment process. Initial contact was made through snowball sampling with two potential female participants who expressed interest in the research; however, neither of them chose to ultimately participate in the study.

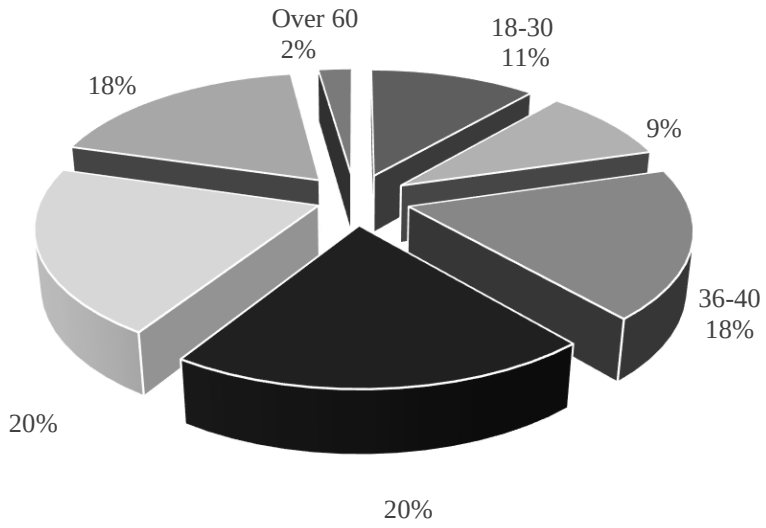
Age

The interviewees ranged in age from 28 to 62 years old. Approximately 39% of the total participants (n = 17) were aged 40 years or younger, and the number of firefighters aged over 40 years accounted for 61% (n = 27) of the sample. Figure 1 presents a detailed breakdown of the participants' age into seven different age groups: 18–30, 31–35, 36–40, 41–45, 46–50, 51–55, and over 60 years. None of those interviewed fell into the 56–60 age group.

Although this research did not examine generation-specific traits, it did examine the generational make-up of the sample. Only one member of the sample was a baby boomer (n = 1), and none of the interviewees were members of Generation Z; therefore, the remaining firefighters were either members of Generation X (n = 20) or Generation Y (millennials; n = 23). The generational groups are mentioned to provide additional context beyond just numerical age.

Figure 1

Participants' Age

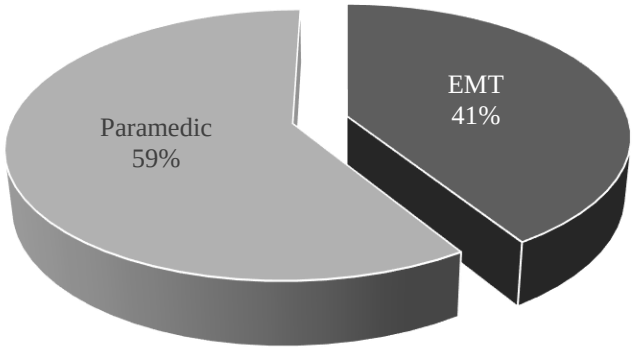


Skill Set

The demographic question regarding skill set was focused on the specific emergency medical training that each person possessed. Although the two cities fall into different geographic counties, they have minimum standards for certification administered by the local EMS agency, which oversees the delivery of EMS within that geographic area. EMT or PM was the minimum EMS provider certification level of the interview participants. EMTs provide basic life support whereas PMs provide advanced life support. Both EMS skill sets are trained to provide care to cardiac arrest victims regardless of patient location. In addition to being CPR trained, people with both skill sets are familiar with the application and use of AEDs. As Figure 2 indicates, there were more PMs (n = 26) than EMTs (n = 18). However, the number of PMs and EMTs from each represented city was identical: nine EMTs and 13 PMs in Anaheim and Riverside.

Figure 2

Skill Set of the Firefighters



Professional Rank

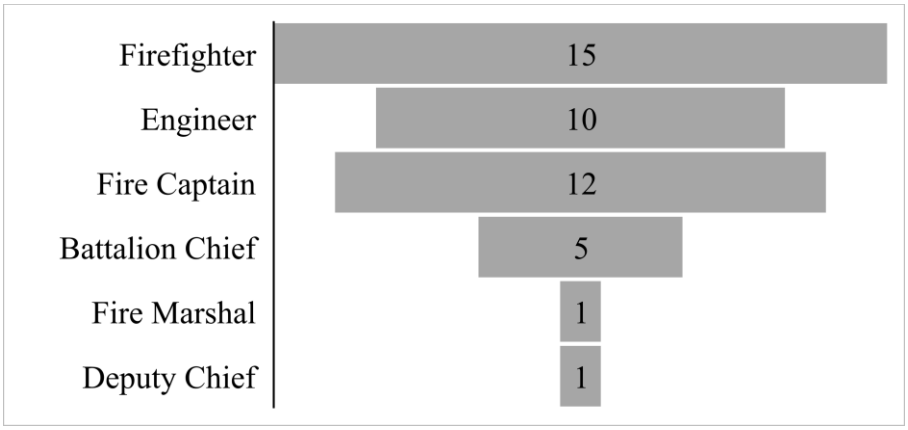
A variety of ranks were represented in the group, ranging from firefighter to deputy fire chief. The less-tenured interviewees encompassed much of the firefighter rank; 12 of the 15 interviewees had less than 15 years of experience whereas 11 of those had less than 10 years. The rank structure starts with the firefighter being the entry-level position; the engineer or fire apparatus engineer is responsible for driving the fire apparatus; the fire captain is the first-level supervisor; the battalion chief is the next level of supervisor; the fire marshal is a chief officer responsible for fire prevention; and the deputy chief is the highest rank below the fire chief.

Generally, the firefighter, engineer, and fire captain ranks are responsible for 9-1-1 emergency response for the seven represented fire departments. The firefighter rank accounted for 34% (n = 15) of the interviewees. Some of the fire captains interviewed were currently assigned administrative roles and not regularly assigned to emergency response functions. The chief officer ranks of battalion chief, fire marshal, and deputy chief represented 16% (n = 7) of the interviewees. The battalion chief rank may respond

to emergency incidents for command-and-control responsibilities, and the fire marshal and deputy chief are administrative chief officer positions. Figure 3 presents a visual representation of the rank distribution.

Figure 3

Rank Within the Department

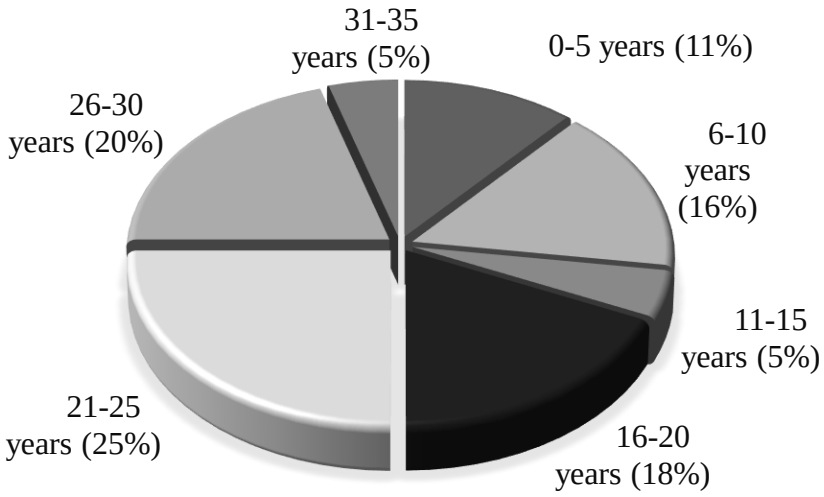


Years of Experience

The interviewees' years of experience ranged from as little as 1 year up to 35 years. The overall distribution of years of experience revealed that 50% of the sample (n = 22) possessed 20 years of experience or less, and the other 50% (n = 22) had 21 years or more of experience. The firefighters living in Riverside (n = 11) and Anaheim (n = 11) were equally represented in the group with under 20 years of experience. Similarly, the firefighters living in Riverside (n = 11) and Anaheim (n = 11) were equally represented in the group with 21 years or more of experience. The total years of experience for the Anaheim residents was 382, and it was 464 for the Riverside residents, with a cumulative total of 846 years of service for the groups. Figure 4 presents a visual representation of the interviewees' years of experience.

Figure 4

Years of Experience

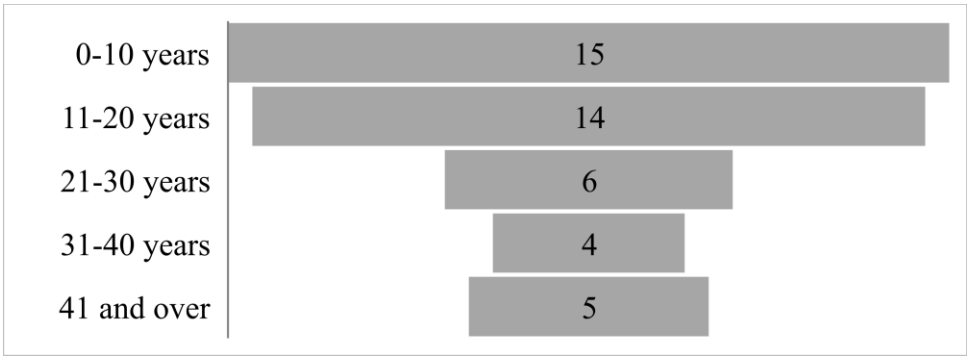


Years Living in the City

The most considerable portion of the sample had lived in their respective cities for 20 years or less, and 34% (n = 15) of the firefighters had lived in their respective cities 21 for years or longer. One of the Anaheim residents had lived in the city for 49 years, and one of the Riverside residents had lived there for 51 years. Both individuals had been in the city since birth. Over half (n = 12) of the Anaheim residents had been in the city for 10 years or fewer. The cumulative years living in the city for the Anaheim residents (n = 22) was 322, and the figure was 519 years for Riverside residents (n = 22). Figure 5 graphically displays the interviewees' number of years living in the city.

Figure 5

Years Residing in the City

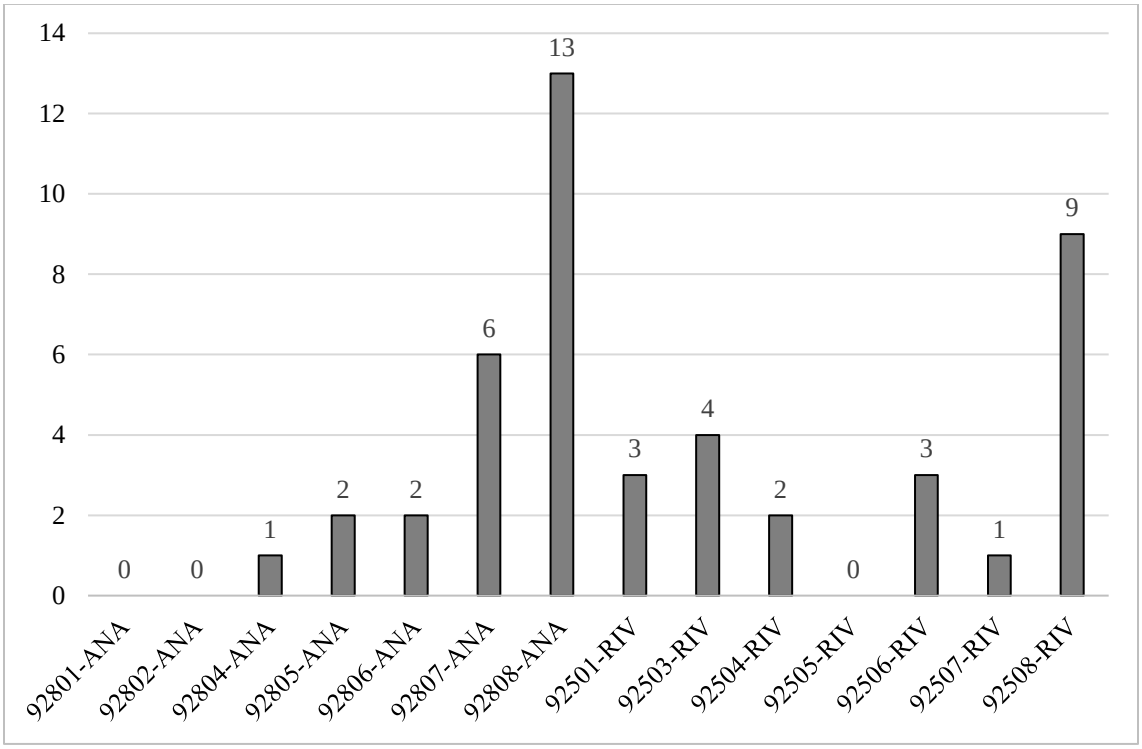


Residential ZIP Code

The final demographic question identified the ZIP code where the firefighters lived. Both Anaheim and Riverside have seven residential ZIP codes. The ZIP code was selected as a demographic data point to examine correlations with electronic patient care report information that captured the ZIP codes of cardiac arrest patients. The firefighters living in Anaheim resided in four of the seven ZIP Codes, and the most significant number lived in 92808 (n = 13). The firefighters living in Riverside resided in five of the seven represented ZIP codes, and the largest number lived in 92508 (n = 9). The two most populated ZIP codes where firefighters lived were 92508 and 92808. These two ZIP codes accounted for 50% (n = 22) of the firefighters interviewed. The demographic information of which ZIP codes the firefighters resided in is further evaluated later in this chapter. Figure 6 presents a visual representation of the residential ZIP code distribution of the 44 interviewees.

Figure 6

ZIP Codes of Residence



Note. ANA = Anaheim; RIV = Riverside.

Interview Questions

This section presents an analysis of the findings from the semistructured interview questions. The findings and themes are provided and supported by relevant quotes and visual characterizations of the outcomes.

Interview Question 1

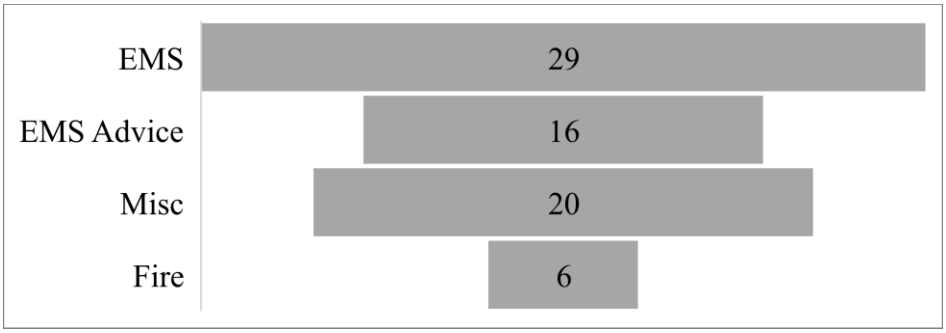
Explain your experience with applying your professional skills outside of the workplace.

Interview Question 1 sought to establish a baseline for whether the interviewees had historically applied professional skills outside of the workplace. It was left broad in focus to allow all skills to be identified, not just those centered on emergency response.

All 44 participants in the research answered this question. Every participant performed one or more job-related skills outside of the traditional workplace. The most common example was providing EMS to victims in various medical emergencies. Four primary points of focus emerged, as seen in Figure 7.

Figure 7

Skills Provided Outside of the Workplace



The severity of EMS care ranged from treating a minor trauma injury to providing lifesaving care for choking patients, and specifically mentioned was the Heimlich Maneuver (n = 3) for clearing an airway obstruction caused by a foreign body. Additionally, CPR for the victim of a sudden cardiac arrest was provided by 14% (n = 6) of the firefighters. The most frequently referenced EMS care provided occurred following motor vehicle accidents, as mentioned by over a third of the interviewees (n = 16).

The skill of EMS advice was also frequently referenced and provided to family, friends, and neighbors who made contact by phone or in person at the interviewee's private residence. If EMS manipulative skills and EMS advice are examined as a single topic of EMS, this skill was referenced in 89% (n = 39) of the feedback to Question 1.

The applied "other" skill set included various answers, such as leadership, teaching, problem solving, coaching, construction, media relations, interpersonal interaction, and politics. These examples indicate the variety of professional skills the respondents frequently apply outside of the workplace. One interviewee referenced an applied skill as follows: "I would say that the organizational skills used to handle specific tasks in chaotic situations transitions over to off-duty life" (RIV-D6-FF2-EMT).

The final skill that was referenced but with less frequency was responding to fire-related incidents when off duty. Only 14% (n = 6) of the 44 interviews mentioned dealing with a fire-related call when off duty. The details of fire-related calls included structure fires and wildland fires.

Question 1 determined whether the sample had engaged in off-duty responses and what professional skills they may have applied in when doing so. The primary theme that emerged was that all the firefighters had performed actions when off duty, and many had done so multiple times. The majority had engaged in providing some level of EMS treatment or advice. Though the magnitude and severity of incidents varied, this finding indicated a willingness by all participants to engage to some extent. The following two questions examined which additional conditions support involvement as well as which may hinder or preclude off-duty participation and response.

Interview Question 2

What factors would make you want to render CPR voluntarily when off duty?

Interview Question 2 was an evolution of Question 1 that sought to identify whether any specific factors needed to be in place to elicit a response specifically to cardiac arrest victims.

All 44 participants in the research answered this question. The most frequent response to this question was having the essential ability to help; over half (n = 23) of the interviewees indicated this as a factor to engage. Several interviewees also offered pertinent comments about rendering CPR centered on altruism and a general focus on humanity.

ANA-D1-FF1-PM said, "That is just my personality, is always wanting to help." RIV-D6-FF11-PM said, "I want to help my fellow man." RIV-D6-FF21-EMT said, "Humans should help humans." RIV-D3-FF14-PM stated, "I feel I have that duty, just to help another human being." RIV-D6-FF20-PM said, "I think we as humans, we all want to help each other."

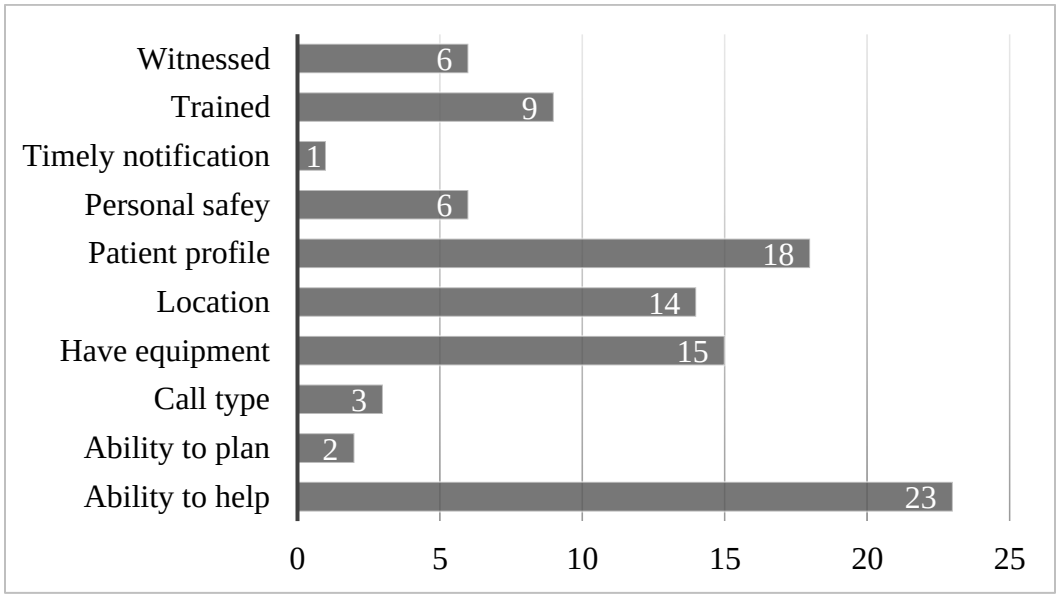
In addition to the ability to help, several other conditions would make the interviewees want to render CPR when off duty. Specific details about the patient were coded as patient profiles and were referenced by 41% (n = 18) of those interviewed. Willingness to render CPR and patient profile included the rescuer's relation to the patient. Examples of the patient profile include someone who was known to the rescuer, such as family members, friends, and neighbors. There was little hesitation by the interviewees about responding to and assisting their neighbors. Other elaborations of the patient profile included knowing the victim's age or knowing that the victim was a child. Several individuals stated that the patient being a child would increase their desire to provide aid. Last, known drowning patients and witnessing the emergency were indicated as additional factors needed to assist with care voluntarily.

Furthermore, the physical location of the emergency and having the appropriate equipment were frequent responses for inspiring an off-duty firefighter to respond.

Location specifics included proximity, safe location, ease of access, and known location. The desire for appropriate equipment was explicitly focused on access to personal protective equipment (PPE) and AEDs by 34% (*n* = 15) of respondents; both topics were referenced again in later questions. Having access to PPE and an AED would make the off-duty firefighter want to assist. Being appropriately trained was also referenced by 20% (*n* = 9) of the respondents. Figure 8 provides a visual comparison of the factors required to provide CPR.

Figure 8

Factors for Rendering CPR



Each firefighter's level of EMS training and certification were previously identified in the demographic questions. Feedback focused on training included the following comments:

- ANA-D4-FF9-EMT said, "I am trained to do it."

- ANA-D2-FF18-PM said, “Just knowing the importance of perfusing the brain early, I would say that would be one of the reasons I would assist.”
- RIV-D6-FF17-EMT asserted, “I could use my skills and knowledge.”
- ANA-D4-FF21-PM stated, “I would like just to be able to use my skills and experience.”
- ANA-D2-FF11-PM said, “So, having that kind of training and being able to help somebody, that is why we all want to do this.”

Other responses (n = 6) to the indicated positive engagement mentioned whether the emergency was centered on the importance of safety. RIV-D6-FF20-PM stated, “I need overall safety. I want to help everyone, but I also want to return to my family.”

The predominant theme from Question 2 was that firefighters have an essential humanistic desire to help cardiac arrest victims when supported by their professional training. The desire to help is further supported when some of the details concerning the emergency, such as location and patient profile, are known. Last, access to equipment increased their willingness to assist. Overall, these matters impacted the interviewees’ willingness to render CPR voluntarily. This theme is further examined under Question 5, which focuses on core values. In addition, the themes of access to equipment, patient profile, personal safety, and incident location reoccur under later questions.

Interview Question 3

Your primary profession is centered on helping others; what conditions would preclude you from doing the same when off duty?

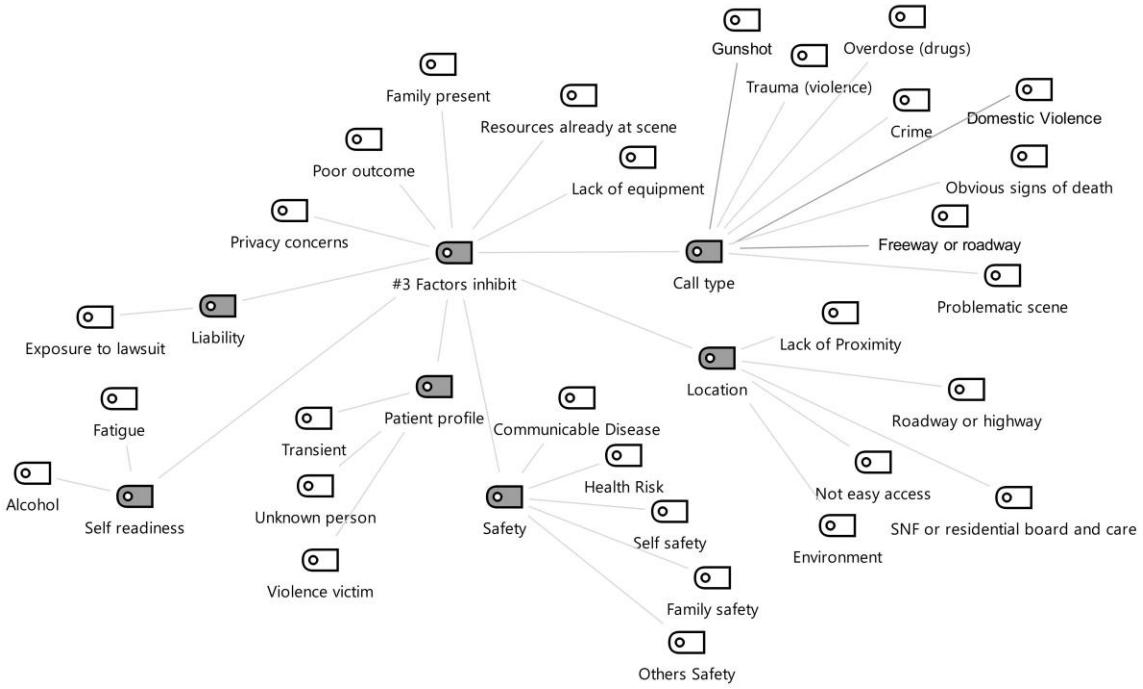
Interview Question 3 sought to provide the interviewee with a counter-narrative to Question 2. Question 2 was a positive affirmation of the off-duty response, but

Question 3 centered on negative response implications and factors that would make an off-duty firefighter unwilling to respond. The responses to Question 3 were considerably more detailed than those for Question 2.

All 44 participants answered this question. Some similarities in the hierarchical coding existed with the previous question, including patient profile, call type, incident location, and safety appearing again under Question 3. However, the subcodes indicated specific details that would preclude off-duty firefighter engagement. A code model was created to demonstrate the variability of the responses, which is presented in Figure 9.

Figure 9

Code Model for Preclusion



The most significant amount of feedback was centered on safety: 86% (n = 38) of the firefighters interviewed referred to safety as a condition that would preclude them

from helping others. The topic of safety was focused on the three themes of self-safety, family safety, and the safety of others.

Half (n = 21) of those interviewed identified self-safety as a barrier to their response. Self-safety was further refined to include communicable disease exposure and other health risks. Some individuals shared specific exposure concerns, such as hepatitis, tuberculosis, and scabies, and others spoke more broadly about communicable or infectious diseases. ANA-D2-FF18-PM stated the following regarding the risk of personal exposure:

> Exposure, that would be probably one of the biggest deterrents for me personally. We do a risk assessment of risk versus gain every single day at our jobs, on every call. Am I going to expose myself and my health on a cardiopulmonary arrest if I render aid? So, hands-only CPR minimizes the risk, and there are not many disease exposures in just doing that. Now if we started getting into more bleeding management, that would be a different story.

Explicitly addressing the concerns of having a family present or apprehension for family safety occurred in 64% (n = 28) of the responses. The feedback was centered on not wanting to jeopardize, endanger, or harm any member of their family.

> RIV-D3-FF4-EMT elaborated on the impact of having family present as follows: I think one of my biggest things right now is having kids with me, having young kids, I am always with them. It would be tough for me, if I was driving and I got pinged to help in a neighborhood that I am driving through. If I am with my kids, there is not a chance that I am stopping. You know, even with traffic collisions, my wife jokes with me. She says, you are a bad off-duty firefighter. Well, I am

> not stopping on the freeway with the family, with a van full of kids for this little fender-bender traffic collision, it is just not going to happen.

RIV-D6-FF20-PM added to the family safety topic by focusing on his children:

> I would feel horrible as a parent and father if my helping someone else caused something to happen to my kids. They are kids, and they are curious; what if they experience something traumatic? They see me helping someone; they know it is with good intentions. But, if they see something traumatic, their cognitive ability to understand it is just not there.

Other respondents were much briefer and to the point about family being present and their willingness to engage. ANA-D3-FF8-EMT said, "If my family is there. I am not helping." RIV-D6-FF9-PM shared, "I would not want to put my family into an equally unsafe situation or put them where they might get hurt."

The final subgroup in the safety theme was concern for the safety of others. This topic was mentioned less frequently (n = 3). The consensus was that if an off-duty response jeopardized the safety of others, the interviewee would not engage.

Call type was also frequently referenced as a factor that would inhibit a response. Incidents on the freeway or road were the most common: 34% (n = 15) identified call types in these areas as an issue that would make them not want to engage. ANA-D2-FF3-PM summed up the concept as follows:

> So many people die on the road; do I really want to pull over with my whole family in the car, parking on the shoulder when people are already staring at the accident, and then put my life in danger and their life in danger too, all to help a stranger on the side of the road, just out of a good will?

Even though the freeway or road call type was a hinderance for many of the respondents, Question 1 revealed that the off-duty response to emergencies on the roadway were performed by 36% (*n* = 16) of those interviewed.

Other call types that were mentioned as a potential barrier for the interviewees included crime (*n* = 9), drug overdoses (*n* = 8), gunshots (*n* = 6), unknown trauma from violence (*n* = 5), and domestic violence (*n* = 5). If these call types are grouped as an overall call type of "criminal in nature," then numerous unique respondents (*n* = 20) commented. Therefore, 45% (*n* = 20) indicated that criminal call types were an inhibiter of off-duty response. In addition, the patient profile was another component of call type that was mentioned as possibly hindering engagement. Victims of violent crime were identified as a concern, creating a link to safety. Transients and patients unknown to the rescuer were also identified as having a potential negative impact.

Self-readiness was a concern for 23% (*n* = 10) of the interviewees. This concern was characterized as either being fatigued or having recently consumed alcohol. In both cases, the firefighters indicated that those reasons would hinder their willingness to participate. ANA-D1-FF1-PM shared the following: "I feel like I would always be on duty. You know that is going to be the biggest challenge. I think, with something like this, work-life balance, fatigue, and health are concerns."

A final barrier to helping others when off duty was concern regarding liability and exposure to lawsuits. Relevant statements included the following:

- ANA-D2-FF18-PM said, "What would make me not want to help? The biggest one would probably be liability. Because I am a medical professional, I am still held to my scope of practice when I am off duty."

- ANA-D1-FF14-PM added, “I would say the legal ramifications is something that’s going to deter me.”
- RIV-D2-FF18-PM shared specific liability concerns concerning to whom and where the response is provided: “Then is there a legal side to it? The question of, why did you respond for this person and not this one? Or, why this house? Why didn’t you choose that house to go to?”

Moreover, one interviewee countered the liability concerns; specifically, ANA-D4-FF6-EMT said that he “feels no fear of liability providing CPR due to his training and experience.”

The most prevalent theme was that of safety, which was characterized as self-safety, family safety, and others’ safety. Secondarily, the incident call type was again an essential topic for the firefighters interviewed.

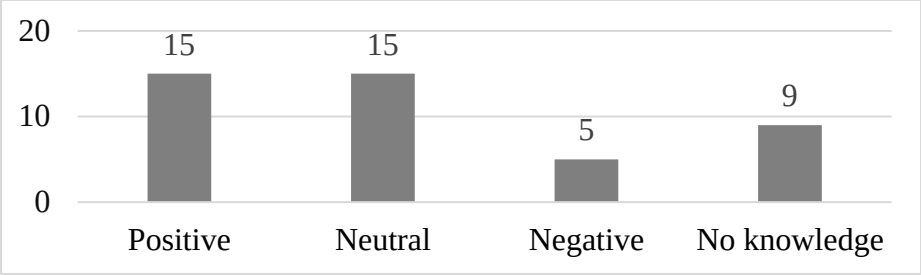
Interview Question 4

Tell me about the positive and negative experiences you have had with crowdsourced lifesaving technologies.

All 44 participants in the research answered this question. However, not all of them had experience using crowdsourced emergency response technology. Those who perceived the technology as positive were the same as those who perceived it as neutral (n = 15). Those who described a negative experience accounted for 11% (n = 5) of the overall response. Of the 20% (n = 9) with no knowledge or experience of crowdsourced lifesaving technologies, some were Anaheim residents (n = 4), and the others were Riverside (n = 5) residents. Figure 10 presents the distribution of the findings.

Figure 10

Experiences With Crowdsourced Lifesaving Technologies



The positive responses were mostly related to the specific mobile app PulsePoint. Half of the interviewees (*n* = 22) had experience with PulsePoint. The individuals with positive experiences (*n* = 15) liked the rapid notification of emergency calls. When on duty, the user often saw the application performing quicker than traditional emergency dispatching. Some of the other referenced positives included enhanced situational awareness (*n* = 7), the ability for the end user to choose an incident notification type (*n* = 5), and the ability to enable notifications (*n* = 2).

The neutral responses (*n* = 15) included both positives and negatives to crowdsourced emergency response technology and did not have an overwhelming reason to provide an overall positive or negative. Several neutral respondents (*n* = 7) referenced a dispatch notification app called Active 9-1-1, which they believed was possibly crowdsourced emergency response technology, which it is not. Active 9-1-1 is an alerting software commonly linked to an emergency dispatch center.

Last, the negative experiences were commonly related to work–life balance perspectives. Several interviewees focused their negativity on the impacts on their time at home:

- ANA-D1-FF5-EMT said, “It is a constant distraction with notifications.”

- ANA-D2-FF18-PM stated, “I do not want another bell and whistle going off.”
- ANA-D1-FF1-PM said, “It is as if we are going to always be on duty.”
- RIV-D6-FF10-PM agreed: “I would say, now, you are never off duty, and you are almost liable in an entirely different aspect.”

An additional perspective from one of the 11% (*n* = 5) who shared a negative perception of the lifesaving technology was centered on job security. ANA-D2-FF3-PM was the only interviewee who shared this perspective:

> My biggest reservation probably would be job security. I am sure everyone else said the same thing. If we go into contract negotiations and the city says we are getting responders from home on 50% of the full arrests. These people are beating you into the call. Why should we give you guys a raise when they are doing your job? They are doing it faster, maybe even better.

Although this participant believed that many would share his same job security concerns, this was not the case because he was the only person troubled by the premise.

The findings for Question 4 had a variable distribution of experiences that included positive, neutral, negative, and no experience. Another theme that emerged was related to the term “Ricky Rescue,” which is a derogatory descriptor for an overenthusiastic nonprofessional helper, and this could be a negative byproduct of crowdsourced lifesaving technology. The topic was discussed in 18% (*n* = 8) of the interviews. It was prevalently used by the off-duty firefighters living in Anaheim (*n* = 6) and less commonly by Riverside residents (*n* = 2). It appears to be a common industry term as the comments were derived from interviews with multiple fire departments; Fire

Department 3 was the only fire department not represented. ANA-D1-FF14-PM expressed concern concerning those he considered Ricky Rescues as follows:

> You are going to get people that are just a "Ricky Rescue" hoping soon-to-be firefighters, and they are going to go to the traffic collisions and cause more accidents. They will be driving, looking at their phone, maybe causing a second accident. For example, their phone vibrates in an area because it is within a radius of where you are located, they are driving, and they look down and, they hit somebody, worst case, a pedestrian. I think there is good and bad to this technology.

Though the term "Ricky Rescue" was not seen in a significant number of the responses to Question 4, it was an emerging theme that warranted identifying.

Interview Question 5

What aspects of your firefighting profession might influence your adoption of crowdsourced lifesaving technologies?

In total, 39 participants had an answer to this question. Five respondents did not have any feedback for the question or opted not to provide an answer. The individuals were not pressured into answering, and the interviewer moved to the next question if a participant declined to answer. As with Question 2, the most common theme of what aspect of the profession would influence the adoption of crowdsourced life-saving technologies was attributed to why they originally became firefighters—to serve the public and help. Half of those interviewed (n = 22) indicated this to be a core value. Several interviewees provided examples:

- ANA-D2-FF4-EMT asserted, "I think it is our nature, by default, to help."

- ANA-D4-FF13-PM said, “I came into this job to help people as a public servant.”
- RIV-D5-FF12-PM stated, “As fire service professionals, we have the personality to help.”
- ANA-D4-FF22-PM provided the following distinction: “I guarantee there are other people that want to help, but they are not comfortable or confident. I am confident that through my career experience, I can serve by helping people.”

In addition to serving and helping the public, the core value of professionalism was another common response by 27% (*n* = 12) of the participants. RIV-D3-FF19-PM framed his concept of professionalism as follows:

> I think it is just professionalism as an influence. We signed up to do this job because we all care about people within the community, not just within the community but all over. I think, for the most part, firefighters will take action. I think it is just professionalism; you will perform the needed task even when you are off duty.

RIV-D6-FF21-EMT elaborated on how professionalism is an aspect that influences adoption:

> In fire departments, the core values of professionalism and integrity are big ones. We always hear the definition of professionalism is what you do as a person when no one is around. This defines you as a person when no one is looking. So, if I get an alert near my house, how do I not see if I can help and provide early CPR?

Similarly, the premise of a duty to act was also mentioned by 14% (*n* = 6) as being an aspect of the firefighter profession that would influence the adoption of crowdsourced technologies. Problem solving was also indicated as an aspect of being a

firefighter relevant to the topic. RIV-D6-FF9-PM elaborated on problem solving as follows:

> There is an underlying idea that I was put here for a purpose. Whatever the circumstances are outside, we solve problems. Well, I deal with those, and that does not negate the original purpose of wanting to help or be a solution to something, especially when it comes to saving a life. That is our primary mission. The fire service is for the protection of life. If we lose sight of that, then we almost lose sight of the soul of the fire service.

Moreover, a few outliers provided core aspects or values that one may expect from someone in public safety, such as altruism and respect for life. ANA-D4-FF21-PM said the following:

> I guess altruism would be the core aspect of my profession that comes into play, just with my prior education, my experience, and knowing the importance of being there as quickly as possible would impact outcomes off duty. I understand how that works.

ANA-D6-FF12-EMT provided the following compelling statement:

> The human life factor is big you know; life is precious. In any facet of life, whether you are homeless, a rich person or a poor person. My biggest driving force to help someone in that type of situation is just the preciousness of life. I think of the 25 years of experience and hundreds of full arrests; you look in those people's faces knowing that somebody being here a little bit earlier might have made a difference.

The most referenced aspect of the firefighting profession that might influence the adoption of crowdsourced lifesaving technologies was the general ability to help. This was reinforced by firefighters being public servants with a duty to act. Last, various discussions of the concept of professionalism were commonly noted. These observations were explicitly linked to professionalism in the fire service.

Interview Question 6

How does the physical location of an off-duty cardiac arrest impact your willingness to help? For example, is there a difference between a public and a private setting?

All 44 participants in the research answered this question. Most respondents indicated perceiving a difference between a public and a private setting, with 82% (n = 36) answering in the affirmative. Only 16% (n = 7) indicated that physical location had no bearing on their wiliness to respond. A single outlier stated that it is not public versus private locations that make the difference in his response; rather, it is the specific details of the emergency. For context, the term "private setting" in this question was synonymous with a residential setting. It includes occupancies such as single-family dwellings, mobile homes, condominiums, apartments, and other high-density housing.

Of those who stated that no difference existed between a public or private setting, most lived in Riverside (n = 5). Their responses indicated a desire to render aid regardless of the setting. One individual (RIV-D6-FF1-PM) was asked a follow-up question regarding why the location made no difference, to which he stated the following:

> I am completely aware of the benefits of early defibrillation, good-quality CPR, and the effectiveness of an individual performing those skills sooner causes a

greater outcome in the end. I know that there is a good chance of a positive outcome.

The consensus among the smaller group (n = 7) that no difference existed in the location indicated that they had the desire to help regardless of where the help was needed.

Those who indicated that the physical location of an off-duty cardiac arrest would impact their willingness to help provided various supporting concepts. For example, several respondents commented about helping neighbors in a residential setting by providing additional context. RIV-D3-FF14-PM stated the following:

> If I get a notification for one of my neighbors that I am familiar with, and it is a comfortable setting, I will have no second thoughts. But if it comes down in a rougher part of town or is nighttime without good lighting, I guess it all goes back to scene safety. If there are numerous unknowns, it becomes the decision point of risk versus gain.

Similarly, another interviewee (RIV-D6-FF2-EMT) stated the following:

> I think the two are different. So, obviously, if something happens in a public setting, that can be anywhere at any given time. Compared to the private setting, my mind almost instantly goes to my neighborhood and my neighbors in that immediate vicinity. I feel like I have even a greater obligation knowing that I have formal or informal connections, with these individuals being my neighbors. In my time of need, I would expect them to be there for me and vice versa. If I look at it from the perspective of a private residence, I instantly gravitate to my neighborhood. I feel like I would be more obligated to help in my own

> neighborhood, knowing that they are my neighbors, my community. With that connection, I would need to help.

A third interviewee (ANA-D4-FF13-PM) added to the topic as follows:

> A public setting is a no-brainer because there are other people around, and you could assume it is safe. But the private setting puts a new spin on it and brings up the whole safety issue. Am I going to run and start knocking on some random door? I think in the private setting unless I know it is my neighbors and I am familiar with them, I would think twice.

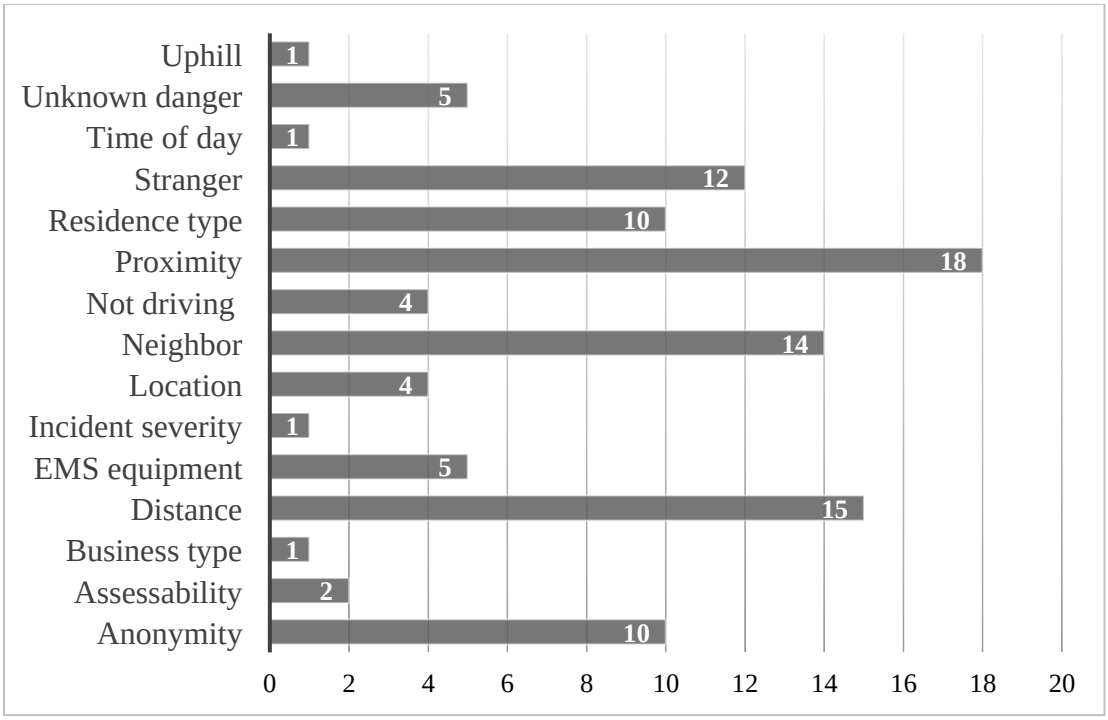
In addition, numerous supporting themes emerged on what might impact the willingness to respond regarding location. A considerable number of interviews (n = 14) indicated that if their neighbors needed help, this would increase their willingness to engage. Neighbor-centric comments include the following:

- RIV-D6-FF10-PM said, "Unless the person calling 9-1-1 gets an alert telling them that I am headed their way, I am not just showing up to a private residence unless it is my neighbor, someone I know."
- ANA-D1-FF1-PM had similar feedback: "Let us say it was a neighbor. I would not have a problem, but if it was somebody I did not know, I would hesitate to respond. It would create a need to consider what I would do."
- RIV-D6-FF8-EMT stated, "If it was in your own neighborhood, where you know your neighbors, you will hesitate a lot less."

Multiple themes emerged from this interview question. Figure 11 visualizes the 15 concepts that were coded.

Figure 11

Differences Between a Public and a Private Setting



Some of these topics overlapped with common themes. Concerns about anonymity, interreacting with strangers, and resident type were frequently mentioned. When on duty, firefighters respond to emergencies in uniform, in groups with other firefighters, and in fire department vehicles. If they responded off duty, they would have none of these things. Several interviewees expressed concerns about their professional anonymity when off duty and being a stranger when responding to a private residence. One interviewee shared the following:

> On duty we responded to people's houses, they call us, we just show up, and they open their door to us. With the off-duty aspect, I would be hesitant to show up to somebody's house unannounced and just say, I am here to help. (RIV-D6-FF5-EMT)

ANA-D2-FF4-EMT added to the theme as follows:

> I am not going to go bust to my neighbor's house trying to perform CPR on them simply from a buzz I get on a cell phone app. Knocking on the door, someone coming out the front, or someone yelling for help, or seeing someone on the ground through the window, that is a different story. So, it is a tough one. Though I believe it is a great tool.

Last, multiple geospatial-related concepts emerged from the public-versus-private discussion, including proximity, distance, location, accessibility, urban versus rural, whether the rescuer needed to drive, and whether the emergency was uphill. While some used distance as a starting point for identifying a difference between public and private locations, it was a secondary issue for others.

Proximity was referenced by 41% (n = 18) of those interviewed. This topic led to a follow-up question that focused on the established distance parameters in the crowdsourced emergency response app PulsePoint. The notification radius for the app is 1/4 of a mile. Several interviewees (n = 8) believed that 1/4 of a mile was too large and should be smaller. Some raised the concept of giving the end-user control of the distance parameters:

> It would help if I was able to manipulate the boundaries. For example, boundaries for the neighborhood across from me compared to another neighborhood where I would have to go through a stop signal and make a couple of turns. It would take much longer to get there than directly across the street in my neighborhood. (ANA-D4-FF21-PM)

Moreover, when asked about specific distance recommendations, some mentioned 1/8 of a mile, and one went as low as 1/16. The idea of allowing the app user to establish an individualized geofence was recommended a few times (n = 5).

Interview Question 7

How could incentives impact your willingness to engage or not engage in off-duty response?

All 44 participants answered this question. The majority (91%; n = 40) felt that incentives would not change their willingness to respond. The four individuals who indicated that incentives would impact their willingness to engage in off-duty response had variable feedback. One of them included multiple aspects in their response:

> If the incentive is you armed me with the training and the skills I would need, the appropriate gear, and the department backing and support, I feel those incentives would help. We live in such a litigious society that if the incentive is that my actions have some sort of liability coverage, that will put some peace of mind to the process. (RIV-D6-FF2-EMT)

Another participant also identified training and equipment as an incentive. RIV-D6-FF20 said, "Most definitely they could help, especially just having an AED and training." The other two firefighters who said incentives would impact their willingness to engage focused on pay and benefits. DIV-D6-FF8-EMT mentioned, "One incentive would be an ongoing pay incentive that was pensionable," while ANA-D2-FF3-PM identified another incentive: "It would be good to get more time off, if you got paid leave hours."

Additionally, 25% (*n* = 11) stated that having a positive impact on a possible life saved was all the incentive they needed. "To me, it is not about an incentive. The incentive is potentially saving someone's life. That is the joy" (RIV-D3-FF16-EMT). Though most of the interviewees stated that incentives would not impact their willingness to engage, a follow-up question was asked about the concept of incentives in general and what may inspire others to respond. Equipment was mentioned frequently, including access to PPE, bag valve masks, and AEDs. Having an AED was mentioned by 23% (*n* = 10) as an incentive. In addition to PPE, injury and liability protection were reoccurring themes in the discussion. A final theme identified was that some might perceive an award or other recognition as a potential incentive. Examples of giving an award at a city council meeting or an annual recognition event were shared.

Other Themes

In addition to the themes and findings for each question, other themes emerged throughout the interview process. The following three additional themes resonated from the research: the concept of being a Good Samaritan, ride-share app correlations, and overall interviewee sentiment.

Good Samaritan

The term "Good Samaritan" was used in two different contexts, the first being the premise of being one, and the other being the concept of being legally protected as one. The topic was identified in 25% (*n* = 11) of the interviews. Most interviewees who commented on the protection of the Good Samaritan law made the distinction that it is for lay persons and not absolute protection for professional responders. However, several respondents believed that the law also provided total liability protection to off-duty

responders. From the context of being a Good Samaritan, the term was commonly linked to the premise of a duty to act. As RIV-D6-FF10-PM mentioned, "Sometimes there is a general duty to act, to be a Good Samaritan."

Correlations with Ride-Share Apps

An unexpected emergent theme was centered on correlations and recommendations linked to ride-share apps. The specific app referenced was Uber, on which one interviewee shared his thoughts as follows:

> So, when you put in a request for an Uber, it goes out to anyone in the area, right? I have a need for a ride, and the message goes out to everybody in a geographic area. Then somebody says, I can fill that need. Once that need has been filled, they send you a picture of your driver and a picture of the car. So, if PulsePoint could do the same thing for these responders, it would be helpful. If you get a PulsePoint activation and it's a residential house five doors from where you are, if you could push a button on your phone that says I am responding, it removes the unknown. (ANA-D4-FF6-EMT)

Another participant expanded on the two-way notification premise between the end user of the app and the 9-1-1 caller through emergency dispatch:

> There could be a button on there that says I am responding as Uber does. So, instead of just saying, a thousand people are looking at this, and I do not know who is responding. Another point is to have it tied to dispatch. Dispatch can see that someone pressed the green button and that they are responding; they can let the 9-1-1 caller know someone is responding. They could say we have a civilian responding by the name of whoever. (ANA-D2-FF17-PM)

A Riverside resident shared the importance of the affirmation of response with the technology again through an Uber comparison:

> You know, these Uber drivers with their phones, they get a job, and they can press a button. Then suddenly you know that Jim is coming from 2 miles away, and he is driving a Toyota, you know his license plate and see a picture. So, if the technology is there and you can press a button, and the dispatcher can let them know there is going to be somebody coming that is not going to wear a uniform, but they are there to help, they are with us. I think that could be beneficial, some positive affirmation of response. (RIV-D3-FF4-EMT)

These findings related to ride-sharing apps identified a possible evolution for the overall use of crowdsourced emergency response technology.

Sentiment

Following each interview, the researcher captured an overall sentiment of the interview. This sentiment was derived from the general tone of the interview. Although this observation was entirely subjective, it was relatively easy to differentiate. The sentiment was captured in three characterizations – namely positive, negative, and neutral.

Positive can be described as an overall willingness to make a positive impact in out-of-hospital cardiac arrests; neutral provided a balanced positive and negative approach to off-duty emergency response, commonly leveraging interviewee-imposed limitations, and parameters; and last, negative sentiment indicated a minimal desire to participate in off-duty responses.

The sentiments among the firefighters living in both cities were similar, and the largest group of those interviewed (n = 21) had an overall positive sentiment toward the concepts of off-duty response. Little difference existed between the two cities across all three themes: neutral was the next most common sentiment (n = 16), followed by negative (n = 7) as the least common. Specifically examining those with a negative sentiment revealed no geographic similarities. The firefighters (n = 7) who were characterized as having negative sentiments lived in six different ZIP codes. The number of firefighters with a generally neutral sentiment was identical in Anaheim (n = 8) and Riverside (n = 8). The overall sentiments of the interviewees are presented in Table 3.

Table 3

Sentiment of the Interviewees

Theme	Anaheim Residents (n = 22)	Riverside Residents (n = 22)	Overall Residents (n = 44)	Percentage
Positive	10	11	21	48%
Negative	4	3	7	16%
Neutral	8	8	16	36%

In addition, no significant demographic correlations were identified across age, professional rank, and years of experience when examining sentiment. A few low-frequency correlations were observed. A linear correlation was observed between the overall sentiment of the entire group and that of the supervisor ranks, which included fire captain, battalion chief, fire marshal, and deputy chief. The collective group was 48% positive, 16% negative, and 36% neutral. The supervisor ranks were similar, with 52% positive, 16% negative, and 32% neutral.

One demographic theme that emerged was the skill set of the predominance of the PM skill set in the negative sentiment: 86% (n = 6) of the off-duty firefighters with a negative sentiment were PMs, and only 14% (n = 1) were EMTs. This figure of 86% was higher than the overall distribution of PMs (59%) in the entire interview group. This negative sentiment could be linked to the aforementioned concepts of work–life balance and fatigue. One PM shared the following thoughts:

> I am exhausted when I go home after I have committed so much time, effort, and energy at work. When I come home, it is time to turn it off. We never get to balance that parasympathetic and sympathetic response at work. We are always in that sympathetic fight or flight mode. I would say I am not planning on utilizing this concept, to be honest, because I am so drained. I am truly exhausted coming home. (ANA-D2-FF18-PM)

Correlations between the participant demographics and overall interview sentiment were also examined to determine whether any themes emerged, which are presented in Table 4.

Although it was worth examining, no obvious demographic factors ultimately emerged as to why an off-duty fighter would have a positive, negative, or neutral sentiment in the interview. Those with a positive sentiment provided feedback that indicated they would have no issue responding off duty if the conditions were established. The individuals with an overall negative sentiment indicated that they were not supportive of the concept of off-duty cardiac arrest response with a few exceptions of care needed by family or friends. Interviewees with a neutral sentiment indicated an

overall willingness to respond to off-duty cardiac arrest emergencies; however, they indicated a much more case-by-case mindset when deciding to engage.

Table 4

Sentiment of Interviewees With Multiple Demographics

Theme	*n*=44	Age	*n*=44	Rank	*n*=44	Experience	*n*=44	Skill set	*n*=44
Positive	21	20-29	1	FF	5	0-9	4	PM	12
☺		30-39	5	FAE	6	10-19	6	EMT	9
Anaheim	10	40-49	11	FC	6	20-29	10		
Riverside	11	50 +	4	BC and up	4	30 +	1		
Negative	7	20-29	1	FF	3	0-9	2	PM	6
☹		30-39	2	FAE	1	10-19	2	EMT	1
Anaheim	4	40-49	2	FC	3	20-29	2		
Riverside	3	50 +	2	BC and up	0	30 +	1		
Neutral	16	20-29	2	FF	7	0-9	5	PM	8
😐		30-39	5	FAE	3	10-19	3	EMT	8
Anaheim	8	40-49	6	FC	3	20-29	7		
Riverside	8	50 +	3	BC and up	3	30 +	1		

Note. FF = firefighter; FAE = fire apparatus engineer; FC = fire captain; BC and up = battalion chief and other chief officers.

Case Study

To further support the findings from the qualitative research interviews, the case study examined cardiac arrest information from the cities where the research participants resided. Basic demographic comparisons for both cities were identified, cardiac arrest data for 2017–2021 were examined, and information from the semistructured interviews was included to identify commonalities and differences among the off-duty firefighters who participated in the research.

City Comparison

Two cities in Southern California were selected to compare in the case study. The cities of Anaheim and Riverside were chosen for the research. They provide similarities and a basis for comparison: First, Riverside has a population of 314,998, and Anaheim has one of 346,824 (U.S. Census Bureau, 2020); second, both cities have their own municipal fire departments that respond to over 30,000 emergency incidents annually; and third, both cities have an assortment of residential, business, industrial, and mixed-use zoning.

The city of Anaheim Fire Department uses a crowdsourced lifesaving technology app called PulsePoint, which it launched on July 1, 2015. The city of Riverside Fire Department is a new adopter of the technology and recently implemented the PulsePoint app with a soft launch on June 29, 2022 (Cit of Riverside, 2022).

Some demographic information was gathered for both cities' focused ZIP codes (see Appendix G). The ZIP code information examined population distributions that are later compared with cardiac arrest frequency and location. ZIP code data are commonly tabulated by the U.S. Census Bureau, the USPS, the Internal Revenue Service (IRS), and the Centers for Disease Control and Prevention (CDC). For this case study, U.S. Census Bureau (2020) information from the 2020 Decennial Census was used for the total city population.

For ZIP code-specific demographic information, the U.S. Census Bureau ZIP code tabulation areas (ZCTAs) were used for a more granular examination of specific demographic information. According to the U.S. Census Bureau (n.d.),

> ZCTAs are generalized areal representations of United States Postal Service (USPS) ZIP code service areas. The USPS ZIP Codes identify the individual post office or metropolitan area delivery station associated with mailing addresses. USPS ZIP Codes are not areal features but a collection of mail delivery routes. The term ZCTA was created to differentiate between this entity and true USPS ZIP Codes. ZCTA is a trademark of the U.S. Census Bureau; ZIP Code is a trademark of the U.S. Postal Service. (para. 1–3)

The ZIP code demographic information was gathered from the CDC Place 2022 release, which includes a model-based ZCTA estimate in a geographic information system–friendly mapping format (CDC, n.d.):

> PLACES cover the entire US—50 states and the District of Columbia (DC)—at the county, place, census tract, and ZCTA levels. It provides information uniformly on this large scale for local areas at four geographic levels. Estimates were provided by the CDC's Division of Population Health, Epidemiology and Surveillance Branch. PLACES was funded by the Robert Wood Johnson Foundation in conjunction with the CDC Foundation. The data sources used to generate these model-based estimates included the Behavioral Risk Factor Surveillance System (BRFSS) 2020 or 2019 data, Census Bureau 2010 population estimates, and American Community Survey (ACS) 2015–2019 estimates. (CDC, n.d., para. 1)

In Anaheim, 92804 is the most populated ZCTA and has the highest population per square mile density. The least populated ZCTA is 92808, which has the city's highest median household income and highest median home value. In Riverside, 92503

is the most populated, and 92501 is the least. The highest median household income and highest median home value are both in 92508. This information is revealed to have correlations with topics later in this chapter.

Cardiac Arrest Information

City-centric cardiac arrest data were requested from the city of Anaheim and Riverside. The information was requested using both cities' public records request portals. The records management system for the city of Anaheim Fire Department allowed for a data query that included the annual total number of cardiac arrests for the 5 years of 2017–2021, the ZIP code where the event occurred, the occupancy type where the cardiac arrest occurred, and whether CPR was provided prior to arrival. Who specifically performed the CPR prior to 9-1-1 arrival was not provided. Similar information was provided from the city of Riverside Fire Department records management system except for occupancy type because the records management system would not support that type of request. The Riverside data were further scrutinized, and whether a family or nonfamily member was performing bystander CPR prior to 9-1-1 arrival was identified. Information from both cities is summarized in the following subsections.

Anaheim Cardiac Arrests 2017–2021

From 2017 to 2021, there were 1,371 cardiac arrests in Anaheim. The yearly total ranged from a low of 220 cardiac arrests in 2019 to a high of 308 cardiac arrests in 2020. The per capita cardiac arrests for the highest year of 2020 were 1 for every 1,126 residents. Additionally, examining each month individually for the 5-year totals, the researcher found that December had the highest occurrence of cardiac arrests with 164,

and June had the lowest with 91. December also accounted for the single busiest month with 57 cardiac arrests in 2020 (see Table H1 in Appendix H).

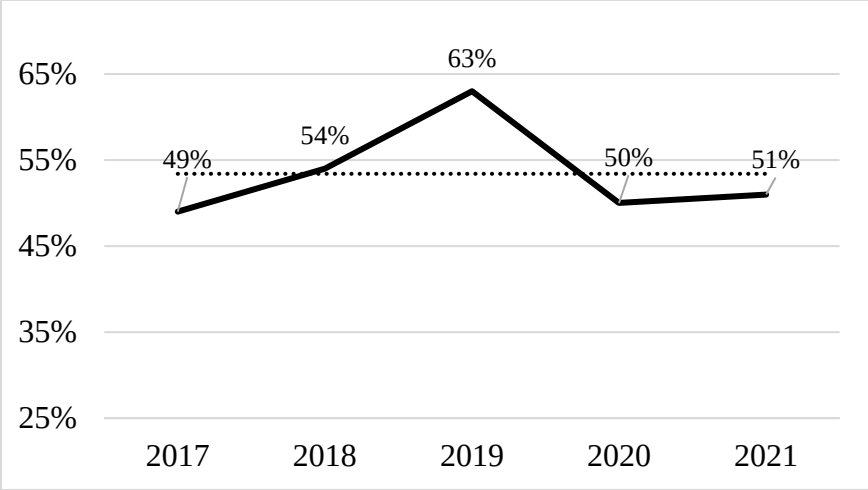
The total cardiac arrests of 1,371 from 2017 through 2020 were also examined by ZIP code: 92808 had the lowest 5-year total with 41 cardiac arrests whereas 92804 had the highest with 358. The single-year low and high occurred in the same ZIP codes with only four cardiac arrests in 92808 in 2019 and a high of 84 in 92804 in 2021. The overall highs and lows exhibited a linear correlation with the ZIP code population data. The most cardiac arrests (n = 358) occurred in the most populated ZIP code of 92504 (n = 89,914). Looking at the single highest year for cardiac arrests in ZIP code 92804 (n = 84), which occurred in 2021, the per capita cardiac arrest rate was 1 per 1,023 residents. Table H2 provides cardiac arrest information by ZIP code.

Bystander CPR was frequently provided to victims of cardiac arrest prior to Anaheim Fire Department resources arriving at the incident. Over the 5 years, bystander CPR was performed on 53% (n = 725) of cardiac arrest victims. The highest overall frequency of bystander CPR prior to arrival was 63% (n = 138) in 2019 whereas the lowest was 49% (n = 143) in 2017. Survivability rates increased when CPR was provided early in the event. The 5-year average for the provision of CPR prior to arrival was 53%. The overall trend line for the same period was static, as observed in Figure 12.

Individual ZIP code CPR rates before arrival ranged from 46% to 63%, and the highest percentage of CPR provided prior to 9-1-1 arrival occurred in 92803, and the lowest occurred in 92808 (see Table H3).

Figure 12

Bystander CPR Rates Prior to 9-1-1 Arrival in Anaheim (2017–2021)



The last group of Anaheim-centric cardiac arrest information pertained to the occupancy type of the location where the cardiac arrest occurred. Additionally, CPR prior to arrival information was examined for each occupancy type (see Appendix I), of which there were 18. Health care facilities encompassed four group types, ranging from medical offices to hospitals. Cardiac arrest in healthcare facilities accounted for 16% (*n* = 213) of the 5-year cardiac arrest total. As expected, CPR was frequently provided prior to arrival at healthcare facilities, and 86% (*n* = 186) of cardiac arrests received CPR before public safety resources arrived at the scene. Only 7% (*n* = 99) of cardiac arrests occurred in private businesses, such as stores or restaurants, where CPR was provided prior to arrival in 66% (*n* = 64) of incidents. Furthermore, transportation-related occupancy types, such as parking lots, railroad tracks, streets, or highways, accounted for 8% (*n* = 111) of cardiac arrests in which CPR was provided in 51% (*n* = 57) of incidents. The most significant occupancy type was residential, including single-family, multi-family, and mobile homes. The residential occupancy type accounted for 63% (*n* = 858)

of cardiac arrests. Bystanders provided CPR prior to emergency responders' arrival in 42% (*n* = 357) of incidents in the residential setting. Appendix I provides information on cardiac arrest by occupancy type.

Riverside Cardiac Arrests 2017–2021

Over the 5 years from 2017 to 2021, there were 1,083 cardiac arrests in Riverside. The yearly total ranged from a low of 175 cardiac arrests in 2017 to a high of 258 cardiac arrests in 2020. The per capita cardiac arrests for the highest year of 2020 were 1 per 1,220 residents. Additionally, examining the 5-year totals, December had the highest occurrence of cardiac arrests with 130, and October had the lowest with 68. December also accounted for the single busiest month of 2020 with 46 cardiac arrests occurring (see Table J1 in Appendix J).

The exact total number of cardiac arrests of 1,083 from 2017 through 2021 were also examined by ZIP code: 92508 had the lowest 5-year total with 76 cardiac arrests, and 92803 had the highest with 221. The single-year high and low occurred in the same ZIP codes with only seven cardiac arrests in 92508 in 2017 and a high of 64 in 92503 in 2021. The overall total high exhibited a linear correlation with the ZIP code population data. The most cardiac arrests (*n* = 221) occurred in the most populated ZIP code of 92503 (*n* = 84,519). Examining the single highest year of 64 in 2021, the researcher found that the per capita cardiac arrest rate was 1 per 1,320 residents in ZIP code 92503. This information is available in Table J2.

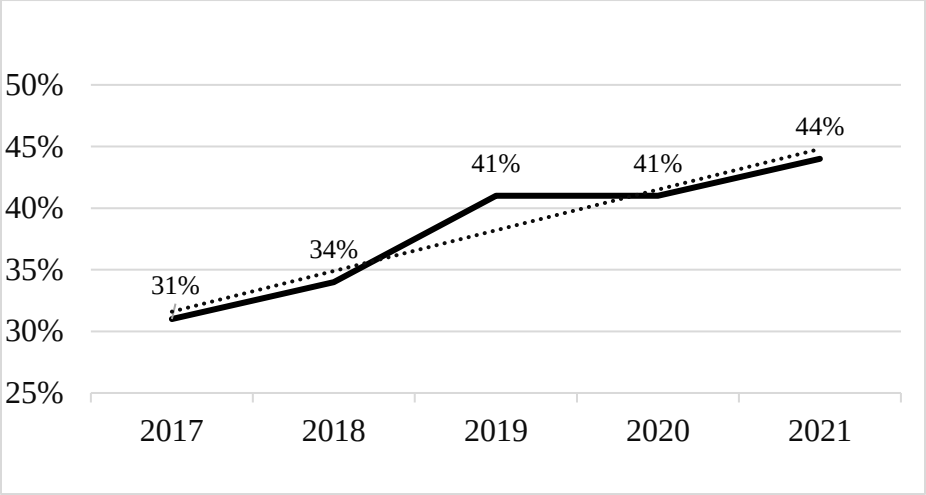
Moreover, bystander CPR was frequently provided to victims of cardiac arrest prior to the Riverside Fire Department arriving at the incident. Over the 5 years, bystander CPR was performed on 39% (*n* = 421) of the cardiac arrest victims. The

highest overall frequency of bystander CPR prior to arrival was 44% (*n* = 111) in 2021, and the lowest was 31% (*n* = 54) in 2017 (see Table J3).

Furthermore, Riverside experienced a year-over-year increase in bystander CPR provided prior to the arrival of 9-1-1 resources. However, the records management system did not provide information on what may have caused the annual increase. Additional research would be required to determine whether a correlation existed with the number of Riverside residents trained in CPR each year. The number of cardiac arrests increased each year, as did the number of times CPR was provided prior to arrival; the difference was the yearly frequency increase. Figure 13 visualizes the 5-year increases.

Figure 13

Bystander CPR Rates Prior to 9-1-1 Arrival in Riverside (2017–2021)



One distinction that the Riverside Fire Department records management system provided was whether CPR prior to arrival was performed by a family member or another bystander. Research has indicated that the highest frequency of cardiac arrests occurs in the residential setting, which may identify correlations with who was providing the CPR

before emergency responder arrival. Although the type of occupancy could not be provided in the Riverside information, who provided the CPR tells a story.

As previously mentioned, overall CPR was provided 39% (*n* = 421) of the time prior to the arrival of 9-1-1 resources. Family members performed 78% (*n* = 328) of prearrival CPR whereas other bystanders provided 22% (*n* = 93). When differences between the various ZIP codes were examined more closely, 92506 was found to have 62% (*n* = 36) family-provided CPR and 38% (*n* = 22) bystander-provided CPR. At the other end of the spectrum, 92503 had 86% (*n* = 81) of family-provided CPR and 14% (13) bystander-provided CPR (see Appendix K).

Discussion

The demographics of the qualitative interview participants, the findings, and themes from the semistructured interviews, and the cardiac arrest data from Anaheim and Riverside created the basis for further insights. Appendix L presents where the interviewees resided in relation to population and cardiac arrest occurrence.

An overall theme emerged that most off-duty firefighters interviewed did not live in populated ZIP codes with frequent cardiac arrests. This was true in both cities: 59% (*n* = 13) of the Anaheim interviews lived in the least populated ZIP code (*n* = 6%) with the fewest cardiac arrests in the city (*n* = 3%); similarly, 41% (*n* = 9) of the Riverside interviewees lived in the second least populated ZIP code (*n* = 10%) with the fewest cardiac arrests in the city (*n* = 7%). Half of all those interviewed (*n* = 22) lived in two ZIP codes that only accounted for 5% (*n* = 177) of the 2,454 cardiac arrests that occurred in the two cities from 2017 to 2021.

Conversely, in Anaheim, the ZIP code with the highest percentage of the city population (*n* = 24%) had the highest number of cardiac arrests (*n* = 26%). A single interviewed off-duty firefighter lived in this ZIP code. The three ZIP codes where no interviewed firefighters lived accounted for 51% of the cardiac arrests. Adding the ZIP code with the singular off-duty firefighter resident encompassed 77% of the total cardiac arrests. The majority (*n* = 95%) of the Anaheim interviewees resided in the three remaining ZIP codes where only 23% of the cardiac arrests occurred. Although some imbalance was observed in Riverside, it was less significant. Like Anaheim, the most populated ZIP code in Riverside (*n* = 25%) suffered from the highest frequency of cardiac arrests (*n* = 20%). However, a much more linear alignment with off-duty firefighters residing in Riverside existed, and 18% of those interviewed lived in the ZIP code with the highest cardiac arrest rate.

Returning to the ZIP code and ZCTA demographics (Appendix G), additional observations could be made. Half (*n* = 22) of the firefighters interviewed lived in the ZIP codes with the highest median household income and median home value. Simultaneously, the ZIP codes with the highest percentage of cardiac arrests were much lower on the income and home value spectrum.

Summary

Chapter 4 discussed the results of the detailed interviews of 44 professional firefighters living in the cities of Anaheim and Riverside in Southern California. These firefighters voluntarily participated in this qualitative study, which was centered on off-duty cardiac arrest response. Seven demographic questions and seven semistructured interview questions were asked of the group. Additionally, a comparative case study of

Anaheim and Riverside was presented because they are similar cities. All interviews were recorded and transcribed and then analyzed for emerging themes. Because of the anonymous nature of the interviews, the participants answered candidly, which created an opportunity to consider a wide range of responses. The upcoming chapter includes the major finding, unexpected findings, conclusions, implications for action, and recommendations for further research.

CHAPTER 5: FINDINGS AND CONCLUSIONS

Sudden cardiac death in the out-of-hospital setting remains a significant issue in the United States. Many of these events occur in private residences and away from any help except for the 9-1-1 system. However, an opportunity may exist to save more human lives. The context of saving a human life is framed as rendering lifesaving interventions, such as CPR and automated external defibrillation (AED), to victims of sudden cardiac arrest outside of the traditional hospital setting. The potential opportunity that may exist is to use crowdsourcing technology to add to the emergency response capacity.

The purpose of this study was to explore the perceptions of off-duty professional firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. The concept focused explicitly on rendering lifesaving interventions to individuals who suffer a sudden cardiac arrest in the residential setting. The crowdsourced notification for the off-duty firefighters to respond would occur through a smartphone notification app. Although the desire to respond comes more from a strategic perspective, the technology that tells the off-duty firefighter to respond arises more from a tactical standpoint. The availability of public safety resources is generally fixed, and leveraging off-duty trained responders could increase survivability.

An understanding of firefighters' perceptions of the topic was captured through semistructured virtual interviews. From these interviews, themes emerged that created an enhanced understanding of end-user engagement and how it could potentially impact outcomes for a representative community. A singular overarching research question was queried, which was as follows: What are the perceptions of off-duty firefighters regarding

crowdsourced emergency response technologies for victims of sudden cardiac arrest in the residential setting?

This qualitative case study focused on sudden cardiac death in out-of-hospital settings. Currently, the only lifesaving resources available to those suffering a sudden cardiac arrest at home are the existing 9-1-1 emergency response system and individuals living in the impacted residence who have been trained to render care. By developing emergent themes that would provide insights into individual responses to sudden cardiac arrest, this study sought to identify opportunities to help solve the problem. Additionally, this qualitative case study aimed to identify the perceptions leading to Pareto optimal/efficient resource deployment. This study focused on firefighters with training and experience as EMTs or PMs and how they perceive off-duty response in their communities. Firefighters who lived in Riverside and Anaheim in Southern California were the focus, and these cities provided similarities and a basis for comparison.

Semistructured interviews were used as the data collection instrument in this qualitative case study research. The semistructured interview questions were designed to capture individual perceptions, and each question was framed to support the research question. The interviews were conducted in a virtual environment, and anonymity was ensured for all participants and their respective fire departments.

A nonprobability design was chosen for the sample because of the specificity of the profession identified. Purposive sampling was selected because the characteristics of the sample group focused on those trained to deliver CPR as a component of their regularly occurring professional duties. The researcher addressed areas in which expectation bias could impact the legitimacy of the purposive sample. Based on the

ability to acquire an acceptable sample size, the study also used snowball sampling because of the specificity of the sample group. The case study analysis added additional insights outside of the qualitative sample group. Furthermore, a comparative analysis of the off-duty firefighters from the two cities added depth to the overall research. By querying the identified sample group on their perspectives on crowdsourced lifesaving technologies, themes emerged that indicated the utility of the technology and areas for evolution.

Major Findings

Throughout the course of the research, several predominant themes emerged. These themes resulted from the interview process and the case study research. The framework of these themes can be categorized into two perspectives, namely an individual perspective and an operational perspective. The individual perspective was further refined into either a service focus or a safety focus, and the operational perspective was further refined into a resource availability focus or a crowdsourced response technology focus. From these themes, future implications were also derived.

Theme 1: Individual Perspective

The individual perspective theme emerged during the 44 interviews conducted with the firefighters. Although the general sentiment of those interviewed was varied, a focus on service and safety emerged. Service and safety remained constant whether the interviewees had a generally positive, negative, or neutral sentiment during the research.

Service Focus

The service focus resonated throughout the qualitative interview process. The interviewees shared examples of how they used their professional skills outside of the

traditional workplace at regular frequencies. Some had engaged in greater volume, but all of those interviewed had experience of performing their professional skills outside of the traditional workplace.

Most of them also shared that providing EMS care and interventions were the most common occurrences. The severity of the injuries occurred across the spectrum from minor injuries to the most severe. Some of the most severe included treating the victims of sudden cardiac arrest. In addition to physically providing EMS intervention and care, providing EMS advice was a skill or service delivered. This service mindset appeared in rendering EMS care and respondents also engaged in firefighting activities when off duty. Though the traditional fire and rescue skills were the most prevalent, other topics were also identified, including teaching, coaching, and the provision of general leadership. All the skills identified were gained from their firefighting profession but regularly delivered when off duty.

The service focus was further supported by the concept of why the individuals initially became firefighters. They frequently shared that their profession is centered on helping others, which is why they are referred to as public servants. A common belief was that they had a duty to act and to engage in society as Good Samaritans with a selfless mindset. Having this as a starting point, this study further identified that the general ability to help motivates the willingness to engage. The group shared that they possess the knowledge, skills, abilities, and requisite training to make an impact. This service mindset was specifically addressed from an EMS perspective. It did not matter whether they performed basic life support services as an EMT or advanced life support

services as a PM. This service focus was a resounding theme from an individual perspective and appeared with all the firefighters interviewed.

Safety Focus

A second finding that emerged from the individual perspective theme was focused on safety. Like the service focus, this concept resonated throughout the interviews and was a recurrent topic for multiple questions. Three distinct modalities characterized the general understanding of safety: self-safety, family safety, and the safety of others.

Self-safety is centered on not being in situations that could result in physical harm. More specifics related to health and safety also emerged, which were related to communicable diseases and exposure. Self-safety was often linked to the physical location or the scene itself, where the emergency may be occurring, which focused on the complexities of unknown environments, unknown locations, unknown circumstances, and unknown individuals. From a self-safety perspective, personal liability was also introduced with regular frequency. A concern was raised that, if individuals responded, would they be safe from personal liability? Most were hopeful that their professional agencies would provide protection and, ultimately, policy development to protect them from liability if they responded off duty and rendered care with the skill sets acquired during their professional duties.

An equally valued safety concern was that of the safety of one's family. This safety mindset shared many similar concerns with self-safety: Was the location of the emergency known? Could they guarantee the safety of their family? Because of these safety concerns, would their family be protected from physical, mental, and emotional harm? The prevailing feedback was that the firefighters would not respond when off duty

if their family were present. They did not believe they could effectively keep their family out of harm's way if they were focused on patient care and treatment. The last characterization of safety was centered on the safety of others. Although this topic was not as common, interviewees mentioned that the responder's choice to engage should not impact the safety of others. Moreover, most interviewees identified a risk assessment as critical to safety determination, and they found the parameters of risk versus gain to bound the engagement.

Theme 2: Operational Perspective

The operational perspective theme also emerged during the 44 interviews conducted with the firefighters. Although the general sentiment of those interviewed was varied, a focus on resource availability and crowdsourced response technology emerged. The identified areas of focus emerged from the interviews and the case study information gathered from Anaheim and Riverside.

Resource Availability

From an operational perspective, the theme of resource availability emerged and was characterized from two different perspectives: one focused on human capital and the other on equipment. The human capital perspective was linked to the availability of trained responders. There is a fixed amount of publicly available emergency response resources, and determining how to optimally leverage off-duty trained responders was a topic discussed frequently. The availability of off-duty responders was directly linked to their physical location, and where they were located when they received an emergency notification to respond was a concern. There was little hesitancy to respond to public locations when off duty. However, the premises of private locations created the need for

more information. Many interviewees expressed reservations about responding in private settings outside of locations where they knew the occupant, even in their immediate neighborhoods. Some exhibited hesitancy toward unknown individuals, which negates the concept of increased resource availability for an off-duty response. Another observation related to resource availability was tied to where the firefighters resided. The examination of both cities identified that most of the firefighters lived in the least populated areas of the city with the fewest cardiac arrests. Even though a willingness to engage could impact survival outcomes, it would not do so on any significant scale because of the residential distribution of those interviewed.

Crowdsourced Response Technology

An additional theme that emerged from an operational perspective was focused on crowdsourced technologies. The nuances of this theme included both positive and negative perspectives and identified some opportunities for evolution. In general, the utility of crowdsourcing technologies for emergency response was validated; even those who dislike the technology's premise see its utility. There was also a varied understanding of how the platforms work. Although most interviewees who possessed experience understood the basic concepts, the details for operational use and optimal outcomes remained unknown. Only two interviewees had a thorough understanding of the smartphone apps, and that was because they were involved in the implementation of the tool.

Those who felt positive saw the potential good that could result from the technology. By contrast, those with a negative perception did not like the potential impacts on their time away from work. Several recommendations for crowdsourced

emergency response technology emerged, including the desire to have greater individual control over the parameters and more opportunities to remove the anonymity of the responder. A specific example of parameter control was to give the end-user the ability to scale and scope the geospatial notification parameters.

Unexpected Findings

When the researcher included the demographic question that asked where the interviewed firefighters lived, it was not anticipated that most of them would live in just a few ZIP codes. Although this finding occurred in both cities, it was more significant for the residents in Anaheim. Most of that group lived in two of seven ZIP codes, and three of the seven ZIP codes had no residents in the interview sample. Riverside had similar findings although not quite as extreme. Nearly half of the firefighters who resided in Riverside lived in a single ZIP code. However, only one ZIP code had no one living in it. This unexpected finding negates the concept that technology creates an equitable mechanism for adding additional resources to existing service delivery models.

Another unexpected finding was how the firefighters characterized the response to sudden cardiac arrests in the private setting. Although they generally supported the premise, it was heavily conditioned with parameters. They expressed little hesitancy toward helping neighbors who were known to them. However, once the concept of it being a stranger they were helping emerged, additional inputs were required for them to decide whether to engage. This is an interesting premise given that their regular duties as firefighters have them engage with unknown people and unknown settings. The reservations were primarily related to the anonymity of off-duty rescuers when not in uniform.

The final unexpected finding was related to incentivizing the adoption of crowdsourced emergency response technologies. Except for a few outliers, the overwhelming feedback was that incentives would not impact their willingness to engage in off-duty response using the technology. The researcher anticipated that incentives would inspire some to participate. However, this was not the case; even the interviewees identified as having an overall negative sentiment were not interested in incentives. In follow-up inquiries, those interviewed provided multiple recommendations and options that could be considered incentives for others.

Conclusion

The research question was "What are the perceptions of off-duty firefighters regarding crowdsourced emergency response technologies for victims of sudden cardiac arrest in the residential setting?"

The predominant position was that off-duty firefighters are comfortable responding to sudden cardiac arrest in a residential setting in certain situations. The belief that they would universally respond to private settings when alerted was found to be false. The conditions for response are highly individualized, but it is safe to say that the technology-based, crowdsourced solution could have an impact by saving lives. Although it is difficult to quantify how many lives would be saved, simply getting resources to the scene faster would improve outcomes.

Implications for Action

The implications for action derived from this study's findings can be characterized as city-centric actions, fire department-centric actions, and technology-centric actions.

City-Centric Actions

The cities of Anaheim and Riverside have both implemented the crowdsourced emergency response technology smartphone app PulsePoint. Continual marketing and education must occur to capitalize on the benefits of this technology. Although its premise is saving lives, it can only be successful if the community adopts and understands how it works. Without an established plan to maintain engagement, the risk exists of poor performance. This research indicated specific areas of the city with a lower propensity for CPR provision prior to the arrival of 9-1-1 resources. Targeted CPR training would be beneficial in these areas.

Additionally, areas with the highest occurrence of out-of-hospital cardiac arrest would benefit from enhanced AED distribution. A strong chain of survival could improve cardiac arrest victims' chances of survival and recovery. The elements include early activation of the emergency response system (9-1-1), early CPR, and early AED.

Fire Department-Centric Actions

Furthermore, this research indicated that greater education is required regarding the how and why of crowdsourced emergency response technology. Most of the interviewees used the app as an extension of their existing fire department computer-aided dispatch programs or as a situational awareness tool. Developing strategies for optimal fire department use could have exponential results in terms of life-saving capacities.

Technology-Centric Actions

In addition, this research found that the end-users of crowdsourced emergency response technologies have variable expectations of their interface with the app. Some of

the existing set parameters were perceived as barriers to adoption for some individuals. Refining the design to meet users' expectations may enhance the app's functionality, simultaneously increasing adoption.

Recommendations for Further Research

Sudden cardiac death in the out-of-hospital setting remains a significant problem in the United States, and many of these events occur in private residences and away from any help. Further research on how to effectively activate the crowd to handle this issue is therefore required. However, little progress is being made to improve outcomes in the residential setting. The outcomes of this research were limited to two similar cities and off-duty firefighters who live in those cities. Thus, similar research should be conducted in other municipalities or possibly in a single fire department where the organizational culture could be added to the research. Similar research could also be conducted in law enforcement agencies to determine the perceptions of off-duty officers responding to victims of sudden cardiac arrest in the residential setting using crowdsourced emergency response technologies. Last, research on how to leverage best practices from nonemergency-centric crowdsourced apps could be beneficial. The volume of data from large platforms, such as Uber, Instacart, and Door Dash, may reveal areas of success that could correlate across other apps.

Concluding Remarks and Reflections

This research focused on off-duty response and validated much of the previous research on the topic of out-of-hospital cardiac arrest in the residential setting. Throughout the course of the research, an enhanced understanding of firefighter perceptions emerged. The firefighters who were interviewed can be characterized as

subject matter experts, and their willingness to voluntarily participate and provide candid insights added to the depth and richness of the findings. The researcher was humbled by the interviewees' willingness to share their personal stories, insights, and observations. One of the most challenging aspects of this research was maintaining objectivity and consistency through the process, which was ensured through creating a process that was replicated for each of the interviews.

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APPENDICES

APPENDIX A

Research Agreement

To: Institutional Review Board, California Baptist University
Date: April 19, 2022
Subject: Consent to recruit from firefighters living in Anaheim, California

To Whom It May Concern:
I, Pat Russell, City of Anaheim Fire Chief, agree to allow Brian Young to recruit participants from the City of Anaheim for the study entitled "Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Firefighters on Crowdsourced Emergency Response." I understand Mr. Brian Young will be recruiting off-duty firefighter participants from various departments residing in Anaheim, California. I understand that individuals may be contacted to solicit their participation in this research project. I am also aware and understand the benefits, risks, and time involved in participation in this study. I understand that individual participation is contingent on voluntary and informed consent.

Brian Young has assured me that no participant names and/or organizations will ever be made public, and all identities will remain confidential. I am fully aware of the procedure and agree to allow interviews to be conducted in the manner approved by California Baptist University's Institutional Review Board (as described in the protocol).

Please contact me if you have any further questions.
Anaheim Fire and Rescue
201 S, Anaheim Blvd. Suite 301, Anaheim, CA, 92805

May 20, 2022

APPENDIX B

Research Agreement

To: Institutional Review Board, California Baptist University
Date: April 19, 2022
Subject: Consent to recruit from firefighters living in Riverside, California

To Whom It May Concern:

I, Michael Moore, City of Riverside Fire Chief, agree to allow Brian Young to recruit participants from the City of Riverside for the study entitled "Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Firefighters on Crowdsourced Emergency Response." I understand Mr. Brian Young will be recruiting off-duty firefighter participants from various departments residing in Riverside, California. I understand that individuals may be contacted to solicit their participation in this research project. I am also aware and understand the benefits, risks, and time involved in participation in this study. I understand that individual participation is contingent on voluntary and informed consent.

Brian Young has assured me that no participant names and/or organizations will ever be made public, and all identities will remain confidential. I am fully aware of the procedure and agree to allow interviews to be conducted in the manner approved by California Baptist University's Institutional Review Board (as described in the protocol).

Please contact me if you have any further questions.
Riverside Fire Department
3401 University Avenue, Riverside, CA, 92501

APPENDIX C

Participant Informed Consent

Study Title: Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Firefighters on Crowdsourced Emergency Response in Metropolitan Cities
Researcher: Brian Young

Dear Prospective Participant,

You are invited to participate in a research study conducted by Brian Young at California Baptist University Online and Professional Studies, Doctor of Public Administration program. I hope to learn how off-duty firefighters value crowdsourced emergency response for sudden cardiac arrest victims in the residential setting. For this study, off-duty firefighters are defined as employees greater than 18 years old, who work as either Paramedics or Emergency Medical Technicians for paid professional fire departments. You were selected as a possible participant in this study because you are a firefighter living in Anaheim or Riverside, California.

What are the next steps once you choose to participate in this study?

- Your participation will involve an online video interview in which you will give your honest response to seven interview questions regarding off-duty emergency response.
- There are six follow-up demographic questions.
- Your participation is anticipated to take 20 minutes.
- Your participation is strictly voluntary.
- If you choose to participate, you may change your mind and leave the study at any time.
- You may skip any questions you do not want to answer.
- Refusal to participate or leaving during the interview process will not result in any consequences.
- Strict procedures are in place to protect your privacy and confidentiality.
- Your responses to the questions will not be linked or identified to you or your organization.
- Your identity and responses will refer to an alphanumeric coding system.
- All video interviews will be recorded for accuracy purposes only.
- Your recorded interview will be downloaded and saved using a password-protected file.
- The file name will refer only to the assigned alphanumeric code and the date of the interview.
- The researcher is the only one who will have access to the cross reference between the alphanumeric codes and participant names.
- This information will never be made public.

- The researcher will destroy all electronic and paper documents five years after publishing the study by shredding paper documents and deleting electronic files.
- You will not be paid for participating in this research study.
- For your participation, you will enter a raffle with the prize of a $500 Visa gift card.
- One raffle prize will be available for the City of Riverside respondents and one raffle prize for the City of Anaheim respondents.
- $5 will be donated to the Firefighter Cancer Support Network for each participant.

We cannot promise any benefits to you for taking part in this research. However, we believe this research may create an opportunity to save more human lives by better understanding emergency response capacity with crowdsourcing technology.

There are no reasonably foreseeable risks, discomforts, or inconveniences because of participating in this research study. Although I do not anticipate any risks, if you experience discomfort, you may contact me (the researcher), or your department Employee Assistance Program.

The researcher is Brian Young. The Chair overseeing this research is Dr. David Hernandez. Please feel free to contact one or both if you have questions, concerns, complaints, feel harmed, or would like to talk to any member of the research team.

This research has been reviewed and approved by the Institutional Review Board at California Baptist University (IRB # 105-2122-EXP). They can be reached at by emailing irb@calbaptist.edu if your questions, concerns, or complaints are not being answered by the research team, if you cannot reach the research team, if you want to talk to someone besides the research team, or if you have questions about your rights as a research participant.

What are the next steps once you choose to participate in this study?
The researcher will need a signed *Statement of Consent* which confirms that the researcher has explained the purpose of this research and the intended outcome.

- The Participant understands that upon receiving the signed Statement of Consent, the researcher will contact me by email to establish a mutually agreeable date and time to participate in an online video interview.
- The Participant understands that the researcher will ask questions about off-duty emergency response.
- The Participant acknowledges that the online video interview is recorded and will be used for research purposes and will not be used outside the research project.
- The Participants participation in this study should take approximately 20 minutes.
- The Participant understands that their responses will be confidential, and that anonymity will be preserved by using an alphanumeric code in all writings related to the research findings.
- The Participant acknowledges that their name and their organization’s name will not be associated with any results of this study.

- The Participant may contact the researchers or irb@calbaptist.edu for additional information or questions.

By digitally signing this form, you acknowledge that you have read the informed consent, you understand the nature of the study, your interview will be audio taped and the potential risks to you as a participant, and your identity will be kept confidential. Your signature on this form also indicates that you are 18 years old or older and that you give your permission voluntarily to serve as a participant in the study described.

x _____.
Please sign here if you consent to participate in the study.

Please email this form back to me if you agree to participate.
I contact you by email to schedule a mutually agreeable date and time to conduct the online video interview.

Thank you for your consideration,

Brian Young, Researcher/ Doctoral Candidate

APPENDIX D

Interview Protocol and Script

Study Title: Sudden Cardiac Arrest in the Residential Setting: The Valuation of Off-Duty Professional Firefighters on Crowdsourced Emergency Response in Metropolitan Cities

Date:
Time of Interview:
Format of Video Interview (Zoom or Teams):

The following provides an outline to guide the interview process for each participant to maintain consistency.

Welcome and overview of session:
Hello and thank you for your participation in my research study on crowdsourced emergency response. My name is Brian Young. I am a doctoral candidate at the California Baptist University, Online and Professional Studies. I am working on a Doctor of Public Administration. You have read, acknowledged, and signed the Inform Consent letter that explains the intent and characteristics of the study, as well as the authorization form to record this interview. I will ask you seven questions regarding crowdsourced emergency response from an off-duty professional firefighter's perspective. There will be six basic demographics follow-up questions. Today's discussion will be conducted within a 20-minute timeframe. When we get close to the end time of the appointment, I will let you know. We will not go beyond that time unless you agree to do so.

Background:

Sudden cardiac death in the out of the hospital setting remains a significant issue in the United States. Many of these events occur in private residences and away from any help except for the 911 system. There may be an opportunity to save more human lives. The context of saving a human life is framed as rendering lifesaving interventions such as cardio-pulmonary resuscitation and automated external defibrillation to victims of sudden cardiac arrest outside of the traditional hospital setting. An opportunity may exist to add to emergency response capacity with crowdsourcing technology.

Purpose:

The study objectives are to explore the valuations of off-duty firefighters when asked to render emergency care outside of the traditional work setting through crowdsourced technologies. The concept focuses explicitly on rendering lifesaving interventions to individuals suffering sudden cardiac arrest in the residential setting. The crowdsourced notification for the off-duty firefighters to respond would occur through a cellular phone notification application. The desire to respond comes more from a strategic perspective, while the technology that tells the off-duty firefighter to respond arises more from a tactical standpoint. The availability of public safety resources is generally fixed and leveraging off-duty trained responders could increase survivability.

An understanding of firefighters' perceptions on the topic will be captured through semi-structured virtual interviews. From the interviews, themes will emerge that create a better understanding of end-user engagement and how that could potentially impact outcomes for a representative community. Off-duty firefighters in this study will be defined as individuals who are over the age of 18.

Ground Rules:

Please be aware, your participation in this study is strictly voluntary, and you may withdraw from the study at any time without fear of penalty or loss of benefit to you. All responses will be kept confidential. For your participation, you will enter a raffle with the prize of a $500 Visa gift card. One raffle prize will be available for the City of Riverside respondents and one raffle prize for the City of Anaheim respondents. Additionally, $5 will be donated to the Firefighter Cancer Support Network on behalf of every participant in the study (for example, 100 participants would result in a $500 donation). Any reference to your responses contributing to the study will be coded and any identifiable information will be removed.

If there are any questions that you cannot answer or do not feel comfortable answering, we can skip over those questions. In addition, I may be taking notes during our conversation and video recording it for a transcript. There are no foreseeable risks to you from participating in this study.

There are no incorrect responses; say whatever comes to mind. I will retain all notes and video interview recordings and no names will appear on the final report. Again, our discussion will focus on valuation of off-duty firefighters on crowdsourced emergency response.

Interview Questions:

1. Explain your experience with applying your professional skills outside of the workplace.
2. What factors would make you want to render cardiopulmonary resuscitation voluntarily when off-duty?
3. Your primary profession is centered on helping others; what conditions would preclude you from doing the same when off-duty?
4. Tell me about the positive and negative experiences you have had with crowdsourced lifesaving technologies.
5. What aspects of your firefighting profession might influence your adoption of crowdsourced lifesaving technologies?
6. How does the physical location of an off-duty cardiac arrest impact your willingness to engage, for example, in a public versus private setting?
7. How could incentives impact your willingness to engage or not engage in off-duty response?

Demographic follow-up questions:

1. What is your age?
2. What is your gender?

3. How long have you been a firefighter?
4. Are you a Paramedic or Emergency Medical Technician?
5. What is your rank within your agency?
6. How long have you lived in the city?
7. What is your ZIP code?

Debriefing:

Thank you for your participation. The information and responses you shared with me today will remain confidential. I will not use your name, your organization name, or any other identifying information in the dissertation. The two raffles for the gift cards will be recorded and available to anyone wishing to see the drawing. Additionally, following the dissertation defense, the final dissertation with be available upon request.

APPENDIX E

Part 1: Demographics of Firefights Interviewed

	Participants (n = 44)	Anaheim Residents (n = 22)	Riverside Residents (n = 22)
Gender			
Male	44	22	22
Female	0	0	0
Age group			
18-30	5	3	2
31-35	4	3	1
36-40	8	2	6
41-45	9	4	5
46-50	9	6	3
51-55	8	3	5
56-60	0	0	0
Over 60	1	1	0
Skill set			
EMT	18 (41%)	9	9
Paramedic	26 (59%)	13	13
Rank			
Firefighter	15	10	5
Engineer	10	5	5
Fire Captain	12	5	7
Battalion Chief	5	2	3
Fire Marshal	1	0	1
Deputy Chief	1	0	1

APPENDIX F

Part 2- Demographics of Firefighters Interviewed

	Participants (n = 44)	Anaheim Residents (n = 22)	Riverside Residents (n = 22)
Experience			
0-5 years	5	3	2
6-10 years	7	5	2
11-15 years	2	1	1
16-20 years	8	2	6
21-25 years	11	5	6
26-30 years	9	5	4
31-35 years	2	1	1
Years in city			
0-10 years	15	12	3
11-20 years	14	5	9
21-30 years	6	3	3
31-40 years	4	1	3
41 and over	5	1	4
Zip code of			
92801–Anaheim		0	
92802–Anaheim		0	
92804–Anaheim		1	
92805–Anaheim		0	
92806–Anaheim		2	
92807–Anaheim		6	
92808–Anaheim		13	
92501-Riverside			3
92503–Riverside			4
92504–Riverside			2
92505–Riverside			0
92506–Riverside			3
92507–Riverside			1
92508–Riverside			9

APPENDIX G

Demographics by ZIP Code and ZCTA

ZIP code	Population *	Population per square mile*	Housing Units*	Median household income*	Median home value*	Square miles*
Anaheim						
92801	62,068	9,872	18,604	$ 47,715	$335,400	6.31
92802	42,709	9.397	12,321	$ 49,099	$367,000	4.55
92804	85,914	12,265	25,717	$ 53,293	$362,600	7.00
92805	70,401	11,167	18,804	$ 53,532	$349,300	6.32
92806	37,173	4,810	12,844	$ 59,315	$416,100	8.07
92807	36,171	3,376	12,893	$ 98,027	$551,300	11.34
92808	20,039	3,943	7,538	$105,144	$603,900	5.08
Riverside						
92501	20,970	3,678	7,827	$ 48,234	$186,800	5.97
92503	84,519	2,830	24,754	$ 56,373	$222,500	34.09
92504	53,778	2,298	17,788	$ 56,108	$220,100	23.47
92505	47,672	3,900	14,573	$ 57,063	$225,900	12.38
92506	44,001	2,716	16,248	$ 78,236	$317,000	16.20
92507	58,002	2,870	19,834	$ 39,465	$232,800	20.22
92508	35,000	3,262	10,351	$100,243	$319,000	10.73

Note. * = Demographics in ZCTA (Centers for Disease Control and Prevention, 2022).

APPENDIX H

Anaheim Cardiac Arrest Tables

Table H1

Cardiac Arrests by Month in the City of Anaheim (2017–2021)

Month	2017 (*n* = 292)	2018 (*n* = 265)	2019 (*n* = 220)	2020 (*n* = 308)	2021 (*n* = 286)	Total (*n* = 1371)
January	29	24	13	30	33	129
February	30	18	25	22	26	121
March	31	22	17	18	27	115
April	23	20	20	20	24	107
May	26	21	19	23	18	107
June	18	16	12	20	25	91
July	23	28	13	22	22	108
August	19	20	25	29	16	109
September	17	26	17	17	18	95
October	19	20	19	20	20	98
November	22	25	17	30	33	127
December	35	25	23	57	24	164

Table H2

Cardiac Arrests by ZIP Code in the City of Anaheim (2017–2021)

ZIP code	2017 (*n* = 292)	2018 (*n* = 265)	2019 (*n* = 220)	2020 (*n* = 308)	2021 (*n* = 286)	Total (*n* = 1371)
92801	46	47	40	51	48	232
92803	60	56	41	51	35	243
92804	70	68	57	79	84	358
92805	55	38	29	49	54	225
92806	21	20	24	35	27	127
92807	33	27	25	32	28	145
92808	7	9	4	11	10	41

Table H3

CPR Prior to Arrival by ZIP Code in the City of Anaheim (2017–2021)

ZIP code	2017 (*n* = 143)	2018 (*n* = 144)	2019 (*n* = 138)	2020 (*n* = 153)	2021 (*n* = 147)	Total (*n* = 725)
92801	22	22	28	28	25	125
92803	41	32	26	37	18	154
92804	34	40	34	38	47	193
92805	23	20	17	19	28	107
92806	5	8	16	12	14	55
92807	14	17	15	15	11	72
92808	4	5	2	4	4	19

APPENDIX I

Location of Cardiac Arrest by Occupancy in Anaheim (2017–2021)

Occupancy type	Cardiac arrests (*n* = 1371)	No CPR PTA (*n* = 646)	CPR PTA (*n* = 725)	Percentage CPR PTA (53)
Health care facility: Clinic, medical office, etc.	12	1	11	92
Health care facility: Hospital	8	1	7	88
Health care facility: Nursing home, skilled nursing	186	26	160	86
Health care facility: Other ambulatory health	7	1	6	86
Industrial: Construction area	1	1	0	0
Institutional: Jail, prison, detention center	1	0	1	100
Other	2	2	0	0
Private business: Store, restaurant, etc.	99	35	64	66
Public building: Police station, other government	2	2	0	0
Recreational: Amusement Park	17	2	15	88
Recreational: Athletic field, gym, etc.	11	5	6	55
Religious institution: Church, temple, mosque, etc.	3	0	3	100
Residential facility: Board and care, group home, etc.	51	15	36	71
Residential: Single family, apartment, mobile home	858	501	357	42
School: Unspecified school	2	0	2	100
Transportation: Parking lot, parking structure	26	6	20	77
Transportation: Railroad track	2	0	2	100
Transportation: Street or highway	83	48	35	42

Note. PTA = Prior to arrival.

APPENDIX J

Riverside Cardiac Arrest Tables

Table J1

City of Riverside Cardiac Arrests by Month (2017–2021)

Month	2017 (*n* = 175)	2018 (*n* = 199)	2019 (*n* = 200)	2020 (*n* = 258)	2021 (*n* = 251)	Total (*n* = 1083)
January	14	24	8	24	32	102
February	21	21	23	21	25	110
March	19	20	19	18	17	93
April	12	13	18	18	20	81
May	12	9	17	20	14	72
June	8	12	20	16	21	77
July	17	16	19	20	18	90
August	17	14	16	19	14	80
September	18	12	17	13	21	81
October	9	15	13	18	13	68
November	13	17	16	25	27	98
December	15	26	14	46	29	130

Table J2

Cardiac Arrests by ZIP Code in City of Riverside (2017–2021)

ZIP code	2017 (*n* = 175)	2018 (*n* = 199)	2019 (*n* = 200)	2020 (*n* = 258)	2021 (*n* = 251)	Total (*n* = 1083)
92501	9	24	12	25	24	94
92503	35	34	39	49	64	221
92504	30	26	24	48	41	169
92505	36	30	30	42	51	189
92506	23	30	40	34	29	156
92507	35	35	41	41	26	178
92508	7	20	14	19	16	76

Table J3

CPR Prior to Arrival by ZIP Code in the City of Riverside (2017–2021)

ZIP code	2017 (*n* = 54)	2018 (*n* = 68)	2019 (*n* = 81)	2020 (*n* = 107)	2021 (*n* = 111)	Total (*n* = 421)
92501	2	7	5	10	14	38
92503	11	14	19	23	27	94
92504	11	9	11	12	14	57
92505	14	15	10	19	20	78
92506	5	9	17	14	10	55
92507	8	8	9	19	14	58
92508	3	6	10	10	12	41

APPENDIX K

Who Provided CPR PTA of 9-1-1 in Riverside ZIP Codes (2017–2021)

ZIP code	2017 (*n* = 54)	2018 (*n* = 68)	2019 (*n* = 81)	2020 (*n* = 107)	2021 (*n* = 111)	Total (*n* = 421)
92501	Family (*n* = 2) Bystander (*n* = 0)	Family (*n* = 5) Bystander (*n* = 2)	Family (*n* = 3) Bystander (*n* = 2)	Family (*n* = 8) Bystander (*n* = 2)	Family (*n* = 7) Bystander (*n* = 7)	Family (*n* = 25) Bystander (*n* = 13)
92503	Family (*n* = 8) Bystander (*n* = 3)	Family (*n* = 14) Bystander (*n* = 0)	Family (*n* = 16) Bystander (*n* = 3)	Family (*n* = 21) Bystander (*n* = 2)	Family (*n* = 22) Bystander (*n* = 5)	Family (*n* = 81) Bystander (*n* = 13)
92504	Family (*n* = 6) Bystander (*n* = 5)	Family (*n* = 6) Bystander (*n* = 3)	Family (*n* = 9) Bystander (*n* = 2)	Family (*n* = 11) Bystander (*n* = 1)	Family (*n* = 12) Bystander (*n* = 2)	Family (*n* = 44) Bystander (*n* = 13)
92505	Family (*n* = 13) Bystander (*n* = 1)	Family (*n* = 11) Bystander (*n* = 4)	Family (*n* = 8) Bystander (*n* = 2)	Family (*n* = 18) Bystander (*n* = 1)	Family (*n* = 18) Bystander (*n* = 2)	Family (*n* = 68) Bystander (*n* = 10)
92506	Family (*n* = 5) Bystander (*n* = 0)	Family (*n* = 7) Bystander (*n* = 2)	Family (*n* = 11) Bystander (*n* = 6)	Family (*n* = 9) Bystander (*n* = 5)	Family (*n* = 7) Bystander (*n* = 3)	Family (*n* = 39) Bystander (*n* = 16)
92507	Family (*n* = 2) Bystander (*n* = 6)	Family (*n* = 7) Bystander (*n* = 1)	Family (*n* = 5) Bystander (*n* = 4)	Family (*n* = 13) Bystander (*n* = 6)	Family (*n* = 9) Bystander (*n* = 5)	Family (*n* = 36) Bystander (*n* = 22)
92508	Family (*n* = 3) Bystander (*n* = 0)	Family (*n* = 6) Bystander (*n* = 0)	Family (*n* = 8) Bystander (*n* = 2)	Family (*n* = 8) Bystander (*n* = 2)	Family (*n* = 10) Bystander (*n* = 2)	Family (*n* = 35) Bystander (*n* = 6)

Note. Bystander refers to all other individual not considered to be family members.

APPENDIX L

Population, Cardiac Arrests Distribution and Interviewee Home ZIP Codes

ZIP Code	ZCTA Pop.	% of city Pop.	% CA	FF (*n* = 44)	% of FF
Anaheim	(*n* = 354,475)		(*n* = 1371)	(*n* = 22)	
92801	62,068	18%	17%	0	0%
92802	42,709	12%	18%	0	0%
92804	85,914	24%	26%	1	5%
92805	70,401	20%	16%	0	0%
92806	37,173	10%	9%	2	9%
92807	36,171	10%	11%	6	27%
92808	20,039	6%	3%	13	59%
Riverside	(*n* = 343,942)		(*n* = 1083)	(*n* = 22)	
92501	20,970	6%	9%	3	14%
92503	84,519	25%	20%	4	18%
92504	53,778	16%	16%	2	9%
92505	47,672	14%	17%	0	0%
92506	44,001	13%	14%	3	14%
92507	58,002	17%	16%	1	5%
92508	35,000	10%	7%	9	41%

Note. ZCTA Pop. = population in ZCTA; % of city Pop. = percentage of city population from ZCTA; % of CA = percentage of cardiac arrests from 2017-2021; FF = firefighters living in ZIP code; % of FF = percentage of firefighters living in ZIP code.