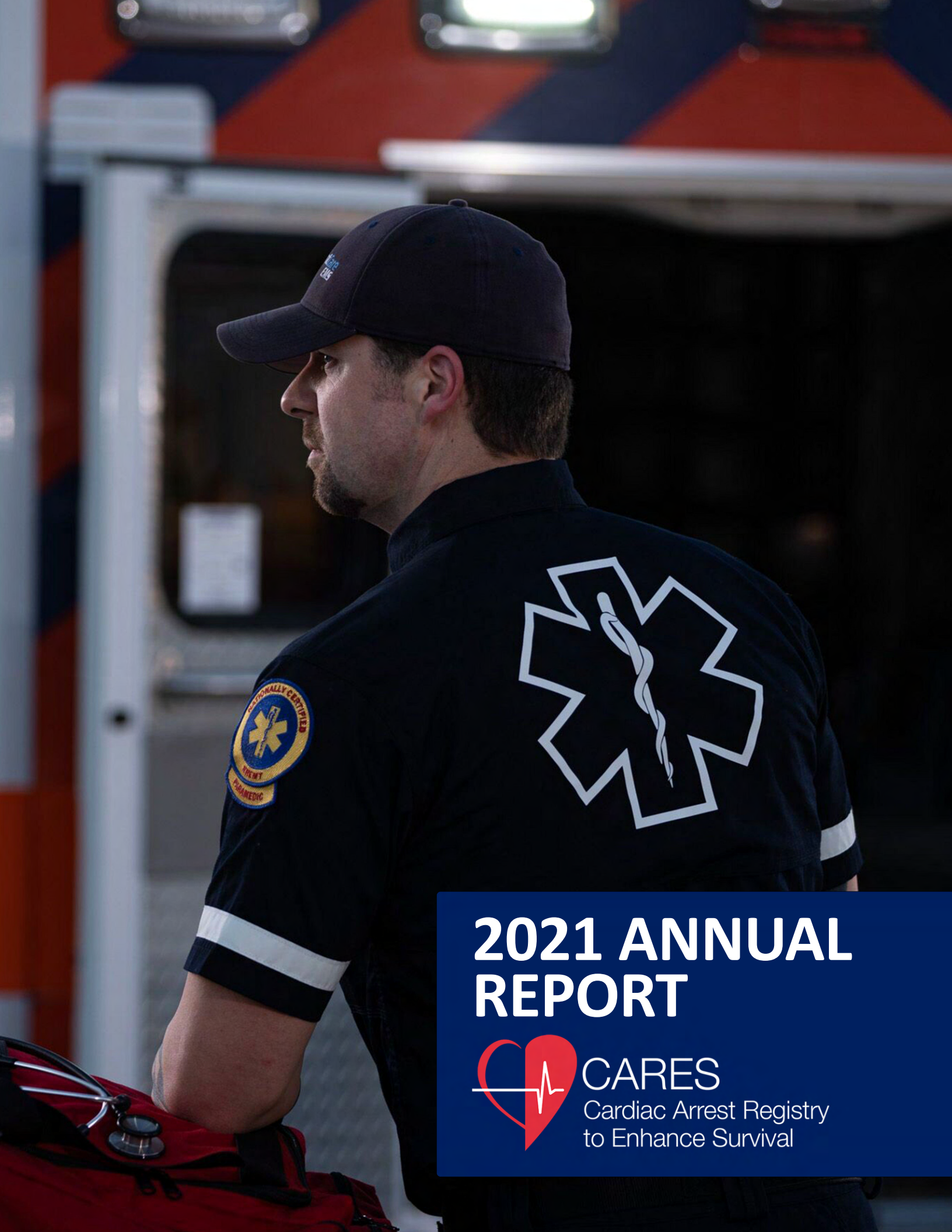

2021 ANNUAL REPORT

CARES
Cardiac Arrest Registry
to Enhance Survival


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STRYKER

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Introduction

EMS-treated out-of-hospital cardiac arrest (OHCA) affects more than 250,000 Americans each year and is the third leading cause of disability adjusted life years (DALY) in the United States, behind cardiovascular disease and back pain. Typically, one in ten patients survives to hospital discharge, with 80% having no or moderate neurological disability. Cardiac arrest resuscitation is an important measure of a community's emergency response readiness. Successful resuscitation requires involvement by a range of individuals including bystanders, emergency medical dispatchers, first responders, paramedics, and hospital providers. Performing bystander CPR can nearly double survival and public access defibrillation results in an almost 50% survival rate for patients presenting in a shockable rhythm. It's important to remember that these impactful community-based interventions happen in advance of 911 responders arriving on the scene.

Without data on key indicators such as patient outcomes and bystander interventions, communities and EMS leadership lack information about how they are performing relative to others, as well as whether their quality improvement efforts are succeeding. Data collection is crucial in identifying gaps and planning next steps to strengthen the chain of survival. OHCA registries fill this role by compiling standardized measures at the community, state, and national level. Benefits of participating in such registries include determining patient outcomes, uniform benchmarking, identifying opportunities for improvement, and assessing the effectiveness of specific interventions[1].

The Cardiac Arrest Registry to Enhance Survival (CARES) allows communities to benchmark their performance with local, state, or national metrics to better identify opportunities to improve their OHCA care. CARES offers a comprehensive understanding of where arrests are occurring, whether bystanders are providing intervention prior to EMS arrival, EMS and hospital performance, and patient outcomes. This in turn provides the data necessary to make informed decisions and allocate limited resources for maximal community benefit. By creating an easy-to-use and flexible system to collect OHCA data and forming a community to share best practices, CARES has transformed the way EMS agencies are treating cardiac arrest. Participating agencies can make decisions in their community based on real-time feedback and analysis, in order to increase survival.

The culmination of CARES occurs during the national reporting process, once the dataset for the calendar year is finalized. Participating states, EMS agencies, and hospitals receive their official CARES reports for the year. For 2021, over 9,500 reports were generated during the three-day reporting process, making it possible for every CARES participant to compare local, regional and national data for benchmarking and surveillance purposes with the goal of increasing survival from OHCA.

We sincerely appreciate the members of the EMS and hospital CARES communities, as well as the sponsors (American Heart Association, American Red Cross, and Emory University Woodruff Health Sciences Center) who support our mission to save lives and improve patient care. We are pleased to present the 2021 Annual Report.

[1] Graham R, McCoy MA, Schultz AM. Strategies to improve cardiac arrest survival: A Time to Act. Institute of Medicine. 2015.

A Year in Review

Dear CARES Community,

2022 promises greater relief and more hope in our communities, states and nation. As I write today, nearly 375 COVID-related deaths are being reported daily in the United States, a sobering reminder of the impact the pandemic has had on our lives since early 2020. In comparison, more than 1,000 Americans experience an out-of-hospital cardiac arrest that results in resuscitative efforts every day, but this is not considered a newsworthy statistic.

We are thankfully seeing stabilization and early evidence of recovery in resuscitation practice and outcomes in the 2021 CARES data. The 14% reduction in survival that occurred in 2020 compared with 2019 (10.5% to 9.0%), stabilized to 9.1% in 2021. Bystander AED use in public locations also recovered to 10.1% last year, up from 9% in 2020 and closer to a pre-pandemic rate of 12.2%. Bystander CPR has been consistent in consecutive years (41.2%, 40.2%, 40.2%).

These metrics and others shared in greater detail within the report emphasize the ***surveillance mission*** of the CARES program. The ***quality improvement mission*** is highlighted in the report with stories about regional and state-level efforts to improve OHCA care in Montana, Nebraska, and Florida. The ***research mission*** has a special section focused on disparities and the local efforts that are attempting to help address health inequities related to OHCA.

In 2021 the CAROL Act (HR 1193) passed unanimously in the House of Representatives and is now under review in the Senate. The bill, named after the late Carol Barr, wife of Representative Andy Barr (R-Kentucky), would provide for funding to both the NIH and CDC, including funding to help expand CARES to all 50 states and for dedicated quality improvement activities nationally. These activities would include community and state-based educational activities such as Telephone CPR (T-CPR) and high-performance CPR (HP-CPR), and operationalizing the NHTSA developed CPR Life Links curriculum. Funding would also be used to modernize the CARES Next Generation Software Platform, allowing for new functionality, greater flexibility and interfacing with the latest data tools.

Finally, I'd like to highlight the CARES video released earlier this year and first shared at the National Association of EMS Physicians (NAEMSP) Annual Conference in San Diego. We are most thankful for everyone who helped make this a reality.

As we transition to the next phase of the pandemic it's important to recognize the value of surveillance data in guiding our public health decision making and performing quality improvement activities locally to increase survival. Our hope is that the recovery we are witnessing nationally will be further improved upon with passage of the CAROL Act and funding that could begin as early as 2023. We greatly appreciate all the local, state and national support that will help in advocating for this federal legislation.

Respectfully,

Bryan McNally, MD, MPH
Executive Director CARES
Professor of Emergency Medicine
Emory University School of Medicine
Rollins School of Public Health

Why CARES Matters: When a Cardiac Researcher's Heart Stops

Cardiac arrest kept Dr. Kevin Volpp's heart from beating for 14 minutes. He's fine now thanks to high-quality CPR, an AED and more. He's sharing his story to inspire people to learn lifesaving skills.

By Jaime Aron, Senior Writer, American Heart Association News

A little after 9 p.m. on a Friday in July, Dr. Kevin Volpp arrived at a restaurant in Cincinnati with his 15-year-old daughter Daphne, her squash coach and some friends. Everyone was tired and eager for a good meal.

Daphne was coming off her second long, intense match of the day, with another the next morning. The tournament was important enough to have lured them away from Philadelphia on the 52nd birthday of Marjorie Volpp, Daphne's mom and Kevin's wife.

Kevin needed to fuel up because he was 16 days from competing in an Ironman 70.3 event. He'd never done anything like it. But when one of his older daughters suggested it, doing something so challenging – and doing it with her – felt irresistible. By this night, he was easily in his best shape since his mid-20s.

Kevin and Marjorie Volpp with daughters Daphne, Anna and Thea in a photo taken upon his discharge from the University of Cincinnati Medical Center in July.

Next to Kevin sat John White, the squash coach at Drexel University, boyfriend of Daphne's coach and himself a squash legend. He'd even been nicknamed, "The Legend." A former world No. 1, his game had been all about power. For years, he held the record for the hardest shot. White ordered the filet mignon and Maine lobster tail. That sounded good to Kevin, so he ordered it, too. Chewing his first bite, Kevin reached for his water but knocked it over. Then he slumped onto the table and tumbled toward White. His heart wasn't beating.

***

What happened next is a story rich in lessons about living and about avoiding death. It's about the importance of knowing CPR, why being fit always helps and what's possible when every link in the chain of survival holds firm.

In November, Volpp – a leader at the University of Pennsylvania's Perelman School of Medicine and the Wharton School whose current research includes a variety of efforts to help people lower their risk of heart attacks – shared his story publicly for the first time at the American Heart Association's Scientific Sessions, the organization's flagship conference. Put another way, thousands of people from around the world who are devoted to keeping hearts pumping heard from one of their own about the day this summer when his heart stopped pumping.

"After the last year and a half, to say we need more wins is truly an understatement," said Dr. David Harris, the attending physician in the cardiac care unit where Kevin was treated. "Kevin is an absolute win. He's a patient I will always remember."

***

Before that fateful dinner, Daphne played two matches. Her second ran so long that their group was late for a dinner reservation. Her coach, Gina Stoker, and White arrived last. Daphne had been seated next to her father, but gave her seat to White. Because of that, when Volpp collapsed and rolled left, White caught him. Placing Volpp back into his chair, White thought his body felt stiff. Stoker immediately called 911. White started giving CPR. He kept going until police took over.

When paramedics arrived, they connected Volpp to an AED, a portable electronic device that analyzes heart rhythm and, if needed, can deliver a shock to try restoring a normal rhythm. The machine advised that a shock was needed. They deployed it, then gave more compressions. After another shock, Volpp's pulse became strong enough to take him to the ambulance. Before driving away, his pulse disappeared again, requiring a third shock.

***

Volpp collapsed because of cardiac arrest. The cardiac arrest was caused by a heart attack. En route, paramedics called the hospital with details. A team was waiting in the cardiac catheterization lab. Doctors found one of his arteries 99% blocked. They performed a minimally invasive procedure that involved inflating a balloon to open the narrowed pathway and inserting a stent to keep it open.

With his body on the mend, the unknown was his brain. He'd gone without a pulse, thus starving his body of oxygen, for about 14 minutes. Permanent brain damage can begin within minutes. Once he regained consciousness, Volpp was confused, as is typical. Yet by Saturday night, he understood all that went wrong with his heart – and he began absorbing all that went right to fix it.

- 911 was called right away.
- White, then a police officer, provided CPR continuously until paramedics took over.
- Paramedics arrived with an AED within 5 minutes of the 911 call.
- The ambulance left 12 minutes later and made it to the hospital in 6 minutes.
- From reaching the hospital until Volpp's artery was open (what's known as "door-to-balloon time") took 1 hour, 8 minutes. The target is less than 1 hour, 30 minutes.

With each successful step, his odds improved. Still, survival rates for cardiac arrest outside of a hospital nationally are around 10%. Harris, the on-site cardiologist, told Volpp the key to his survival was immediately receiving high-quality CPR. "How do you know I received high-quality CPR?" Volpp asked. "Because I'm talking to you 25 hours after the event," Harris replied.

At 7:40 a.m. on Sunday, Volpp tapped out the following text to White: "Hey John, I don't know how to thank you. I think you saved my life. I think I'm doing OK now thanks to you"

***

For a few weeks after his life was saved, Volpp's chest and ribs were sore. "But it was sort of a pleasant reminder of how people helped me survive," he said. "So I didn't really mind." He traded Ironman training for cardiac rehabilitation. A stress test showed no problems stemming from the repaired artery or elsewhere in his heart. He's been cleared to exercise daily. He's even rejoined his triathlon training club.

"I'm choosing to believe the narrative that all these things perfectly fell into place to save my life for a reason," he said. "There's a lot for me to yet do in this world." Such as helping fewer people die of heart disease. Volpp is one of two leaders of a five-year grant from the National Institutes of Health to study how behavioral economic approaches (think, "nudges") can increase physical activity among patients at higher risk of heart disease. He is also leading a multi-project initiative at Penn Medicine on reducing heart attack risk by influencing patient and clinician behavior and has published more than 150 articles on related topics. "It's always been one of my most important efforts," he said, "but now I'm doubling down on it."

Dr. Volpp Calls for EMS Agencies to Participate in CARES After His Cardiac Arrest

During the AHA Scientific Sessions' closing event in November 2021, Dr. Kevin Volpp talked to AHA president, Dr. Donald M. Lloyd-Jones, about the six calls to action that he thinks need to be considered in order to improve out-of-hospital cardiac arrest outcomes. Among the calls to action is for EMS agencies to join the CARES registry. Dr. Volpp experienced his cardiac arrest in Cincinnati, one of the first cities to join CARES. He credits the city's participation in CARES among the reasons why he survived.

"We have the CARES registry which I think many EMS agencies have found to be a very important quality improvement tool," he said. "But only about half the US population is cared for by an EMS agency that participates in CARES now. Participation is voluntary. And funding is not all that stable. So, whatever we could do to incent EMS agencies to be part of the CARES registry and to stabilize funding would really help quality improvement efforts going forward."

Survivors of Cardiac Arrest

In 2021, CARES reported more than 13,000 out-of-hospital cardiac arrest survivors. We are pleased to share the stories of a few, and acknowledge the individuals – dispatchers, bystanders, first responders, paramedics, and hospital providers – involved in saving their lives.

Dalyce Bradshaw

Daniel Arbour,
Houston Fire Department, and
Memorial Hermann Texas Medical Center

Read more of Dalyce's story

Delya Sommerville

U.S. Representative Vicky Hartzler,
US Capitol Police,
DC Fire and EMS, and
George Washington University Hospital

Read more of Delya's story here and here

Doug Schwartz

Shelly Belknap & Steve McGaffick,
Eagle River Fire Protection District,
Eagle County Paramedic Services,
and Vail Health Hospital

Read more of Doug's story here and here

Dustin Drollinger

Andrea Drollinger,
Central Jackson County Fire Protection District, and St. Mary's Medical Center

Garry Vanderberg

Dispatcher Adah Whisman,
Dr. Kelly Tillotson, Oshtemo Township Fire Department, Life Ambulance, and Bronson Hospital

Watch more of Garry's story

Greg Kowalewski

Dr. Jeff Zampi,
Huron Valley Ambulance, and
University of Michigan Hospital

Read more of Greg's story

Kevin Draws

Dispatcher Michelle Allison,
Brevard County Fire Rescue, and
Holmes Regional Medical Center

Luis Perez

Off-duty Police Officer Xenon Berkeley,
Spokane Fire Department, and
Providence Sacred Heart Medical Center

Read more of Luis's story

Mark Stewart

Dispatcher Linda Armendariz,
Sandra McKinzie,
Cedar Hills Fire Department, and
Methodist Mansfield

Mavis Johannes

Reedsburg Police Department,
Reedsburg Area Ambulance,
Reedsburg Area Medical Center, and
UW Madison

Michael Lengyel, Sr.

Dispatcher Leslie Stidham,
Michael Lengyel, Jr., Patricia Lengel, &
Paige McAdams,
Hamburg Police & Fire Departments,
Livingston County EMS, and
University of Michigan

Miodrag Sokovic

Aurora Fire Rescue,
Falck Rocky Mountain, and
The Medical Center of Aurora

Reed Gaines

Marathon County Sheriff 911 Dispatch,
City of Wausau Fire Department, and
Aspirus Wausau Hospital

Seth McDaid

Coaches Clint Watson, Kirk Flynn, &
Jeremy Bartlett, Deputy Nic Rauser,
Broadwater Healthcare Ambulance
Service, and Broadwater-Billings Clinic

Watch more of Seth's story

Stephen Weston

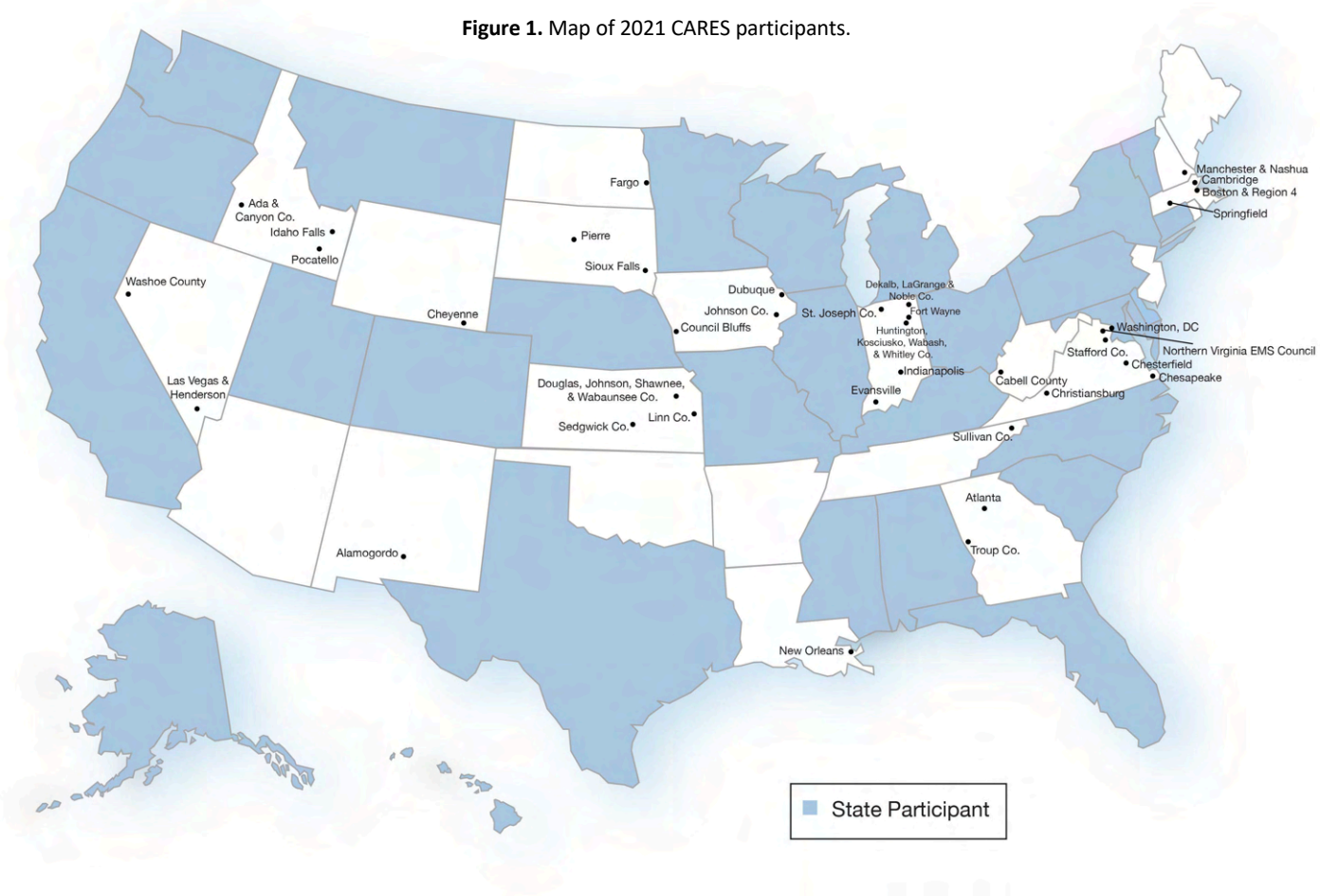
Dispatcher Bethany Fairchild,
Sheryl Weston,
Biloxi Fire Department,
GMR Gulfport, and
Memorial Hospital at Gulfport

The Cardiac Arrest Registry to Enhance Survival (CARES)

In 2004, the Centers for Disease Control and Prevention (CDC) established the Cardiac Arrest Registry to Enhance Survival (CARES) in collaboration with the Department of Emergency Medicine at the Emory University School of Medicine. CARES was developed to help communities determine standard outcome measures for out-of-hospital cardiac arrest (OHCA), by linking the three sources of information that define the continuum of emergency cardiac care: 911 dispatch centers, emergency medical services (EMS) providers, and receiving hospitals. Participating EMS systems can compare their performance to de-identified aggregate statistics, allowing for longitudinal benchmarking capability at the local, regional, and national level.

CARES began data collection in Atlanta, with nearly 1,500 cases captured in 2006. The program has since expanded to include 30 state-based registries (Alabama, Alaska, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Kentucky, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Vermont, Washington and Wisconsin) plus 50 community sites in 16 additional states, representing a catchment area of approximately 170 million people or 51% of the US population. To date, the registry has captured over 800,000 records, with more than 2,200 EMS agencies and over 2,500 hospitals participating nationwide.

Figure 1. Map of 2021 CARES participants.



Case Definition

CARES captures data on all non-traumatic out-of-hospital cardiac arrests where resuscitation is attempted by a 911 Responder (CPR and/or defibrillation). This also includes patients that receive an AED shock by a bystander prior to the arrival of 911 Responders. Inclusion and exclusion criteria are described below (Tables 1 and 2).

Table 1. CARES inclusion criteria (all of the following)
• Patients of all ages who experience a non-traumatic, out-of-hospital cardiac arrest.
• Patients who are pulseless on arrival of 911 Responder; OR • Patients who become pulseless in the presence of 911 Responder; OR • Patients who have a pulse on arrival of EMS, where a successful attempt at defibrillation was undertaken by a bystander prior to arrival of 911 Responder.

Table 2. CARES exclusion criteria (any of the following)
• Unworked/untreated cardiac arrests, to include codes that are terminated immediately upon arrival of EMS because the patient is not a viable candidate for resuscitation due to: ○ Injuries incompatible with life. ○ The presence of rigor mortis or lividity. ○ Signs of decomposition. ○ Presence of a valid DNR.
• Stillborn neonates/perinatal newborns, born without signs of life.
• Private EMS transport that did not involve 911 dispatch.
• Cardiac arrest of clear and obvious traumatic etiology.
• Bystander suspected cardiac arrest, where ROSC was achieved without the need for defibrillation or 911 Responder CPR.

Data Collection & Elements

Data collection within CARES is based on the Utstein-style definitions – a standardized template of uniform reporting guidelines for clinical variables and patient outcomes that was developed by international resuscitation experts[2,3].

The CARES web-based software (https://mycares.net), links three sources to describe each OHCA event: 1) 911 call center data, 2) EMS data, and 3) hospital data. Data can be submitted in two ways: using a data-entry form on the CARES website, or via daily upload from an agency's electronic patient-care record (ePCR) system. Access to the CARES website is restricted to authorized users, who are prohibited from viewing data from another agency or hospital.

Data elements collected from EMS providers include demographics (i.e. name, age, date of birth, incident address, gender, and race/ethnicity), arrest circumstances (i.e. location type of arrest, witness status, and presumed etiology), and resuscitation-specific data (i.e. information regarding CPR initiation and/or AED application, defibrillation, initial arrest rhythm, return of spontaneous circulation [ROSC], field hypothermia, and pre-hospital survival status).

EMS providers are also able to enter a number of optional elements, which further detail arrest interventions (i.e. usage of mechanical CPR device, ITD, 12 Lead, automated CPR feedback device, and advanced airway; administration of drugs; and diagnosis of STEMI). The CARES form also includes a number of optional time elements, including estimated time of arrest, initial CPR, defibrillatory shock, sustained ROSC, and termination of resuscitative efforts. Supplemental data elements collected from 911 call centers include the time that the call was received, the time of dispatch for both first responder and EMS providers, and arrival time at the scene.

Data elements collected from receiving hospitals include emergency department outcome, provision of therapeutic hypothermia/TTM, hospital outcome, discharge location, and neurological outcome at discharge (using the Cerebral Performance Categories [CPC] Scale). Receiving facilities may also complete optional elements outlining hospital procedures,

[2] Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: The Utstein style. A statement for health professionals from a Task Force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. *Circulation*. 84:960-975.

[3] Perkins GD, Jacobs IG, Nadkarni VM, et al. Cardiac Arrest and Cardiopulmonary Resuscitation Outcome Reports: Update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: A Statement for Healthcare Professionals From a Task Force of the International Liaison Committee on Resuscitation and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. *Resuscitation*. 96:328-340.

including coronary angiography, CABG, and stent or ICD placement.

The CARES dataset is geocoded on an annual basis and linked to a number of census-tract level variables including: median household income, median age, race and ethnicity, unemployment rate, poverty status, urbanicity, and educational attainment.

Reporting Capability

The CARES software includes functionality to automate data analysis for participating EMS agencies. The reports include 911 response intervals, delivery rates of critical interventions (i.e. bystander CPR, dispatcher CPR, public access defibrillation [PAD]), and community rates of survival using the Utstein template. An EMS agency has continuous access to their data and can generate reports by date range at their convenience. The software is also capable of aggregate reporting allowing CARES staff to generate custom reports for benchmarking and surveillance purposes. In addition, hospitals have access to facility-specific reports, allowing users to view pre-hospital and in-hospital characteristics of their patient population with benchmarking capability. A robust query feature also allows agencies and hospitals to create customized searches of their data. These search results can be easily exported to Microsoft Excel for further analysis.

Data Validation

The CARES quality assurance process is one of the strengths of the registry, as a number of measures are taken to ensure the integrity and accuracy of the data. These measures include standardized training of all CARES users, built-in software logic, an audit algorithm ensuring consistent data validation across the registry, and a bi-annual assessment of population coverage and case ascertainment.

Training, Education, and Support

Training, education, and ongoing technical and operations support are key components of CARES that contribute to the registry's success and enhance the experience for participating sites. During the enrollment process, EMS and hospital users receive extensive training from CARES staff on the data elements, data collection process, and features of the CARES website. This training includes a one-on-one session with a CARES Program or State Coordinator prior to being granted access to the software. EMS and hospital users are also provided with numerous resources, including a detailed CARES data dictionary and a CARES user guide. Once a community has been participating in the registry for an extended period of time, CARES provides ongoing support in the form of answering questions as needed, providing updated training documents, and responding to individual reporting requests.

Software Logic and Auditing

In order to provide consistent data validation across the registry, each CARES record is reviewed for completeness and accuracy through an automated audit algorithm. Once the record is processed by the algorithm, data entry errors are flagged for review by EMS and hospital users (as appropriate) and CARES staff. Logic and error messages are also incorporated into the data-entry form to minimize the number of incomplete fields and implausible answer choices during the data entry process. Finally, aggregate data is analyzed on a regular basis to identify agency-specific anomalies. CARES staff utilize site-by-site comparison tools to detect outliers and compare each agency's data with the national average.

Case Ascertainment

Each EMS agency is asked to confirm their non-traumatic call volume to ensure capture of all arrests in a defined geographic area. The volume of OHCA per month is compared with historic monthly volumes by CARES staff; when a substantial drop in the number of events occurs, the EMS contact is notified to determine if the variation was real or the result of a lag in the data-entry process. In addition, CARES conducts a bi-annual assessment of population coverage and case ascertainment. CARES staff and State Coordinators provide each EMS agency's geographic coverage, census population, and start date via a standardized template. This information is then linked with record volume to identify outliers across the entire registry. In the event that an outlier is found, CARES staff or the State Coordinator works closely with the EMS agency to identify any issues in the data collection process and resolve as needed.


SONOMA COUNTY
E.M.T.

CARES in Action

Providing Lifesaving Equipment for Law Enforcement First Responders

In order to improve out-of-hospital cardiac arrest survival, The Leona M. and Harry B. Helmsley Charitable Trust has equipped thousands of first responders with modern, life-saving equipment as part of its Rural Healthcare Program. This includes state-of-the-art connected AEDs and LUCAS chest compression systems to aid in CPR, as well as the training needed to use them effectively.

Montana and Nebraska are two Midwestern states that have received Helmsley grants for the distribution of AEDs to all law enforcement organizations, allowing life-saving technology to be placed into the hands of those who can best utilize it. As CARES participants, both states have been able to track the progress of these programs and measure their impact on out-of-hospital cardiac arrest resuscitation efforts within their communities.

The Value of CARES in a Large, Rural State

By Janet Trethewey, EdD, EMT, Montana CARES State Coordinator & Emergency Cardiovascular Care Program Manager

In a large, rural state, Montana EMS agencies and hospitals are presented with unique challenges when responding to out-of-hospital cardiac arrest. With 147,042 square miles, our "Frontier" state is roughly the size of California, but has a population equivalent to the city of San Diego, with 1.3 million residents. Only four of fifty-six counties in Montana have a population greater than 100,000, and the three least-populated counties have 0.3 residents per square mile. In addition, Montana is demographically the oldest state west of the Mississippi River, with nearly 20% of residents ages 65 or older.

The majority of Montana is served by EMS agencies staffed by volunteers with EMT or AEMT licensure, and the rural nature of the state often prevents even the best emergency services from arriving on scene in time to help cardiac arrest patients. The average time to scene in rural areas is more than 14 minutes, and the corresponding transport time is often greater than 20 minutes. Distances to the nearest hospital of more than 20 miles are not uncommon.[4]

In 2015, the state began a partnership with the Helmsley Charitable Trust to develop the Montana Emergency Cardiovascular Care (ECVC) System. The grant allowed Montana to become a CARES state, with initial data collection by seven EMS agencies. From 2016-2019, additional agencies were enrolled in CARES to cover approximately 80% of the state's population. In 2020 and 2021, the Montana CARES State Coordinator abstracted data from ePCR reports submitted by smaller EMS agencies and manually entered these cases into CARES, allowing for nearly 100% capture of all OHCAs in the state.

The ECVC Program is creating a more cohesive emergency cardiovascular system of care in Montana, using CARES data to develop statewide initiatives related to training, community education, and system building. The state has less than 500 non-traumatic cardiac arrests per year, making it difficult to see trends and opportunities for improvement, particularly in low population areas. However, evaluating aggregate, state-level data helps with benchmarking and identifying longitudinal trends.

When evaluating CARES data, we found that more than 70% of OHCAs in Montana occur at home and the majority are unwitnessed.[5] These circumstances, in addition to long EMS response times, translate to prolonged time from arrest to AED application. In February 2020, the EMS and Trauma Systems Office received another generous grant from the Helmsley Charitable Trust to help address this issue. The grant provided funds to equip every law enforcement vehicle in the state with an AED. Law enforcement officers often reach a patient much faster than EMS, especially in rural communities. Even with a scaled back distribution plan due to COVID,

Law enforcement officers receive training on operating their AEDs.
Photo taken by Courtney Perry: © The Leona M. and Harry B. Helmsley Charitable Trust.

[4] Montana EMS Annual Report 2021 – Executive Summary. https://dphhs.mt.gov/assets/publichealth/EMSTS/EMS/EMSannualreport2021.pdf
[5] CARES Registry Data – Montana Reports, 2017-2020.

most agencies had their AEDs installed and officers trained by the end of 2021. One hundred nineteen agencies are participating in the program - 43 municipal, 53 county, 7 state, 5 tribal, 3 campus, and 7 federal - and to date, this initiative has helped place more than 2,100 devices across the state.

With two years of comprehensive statewide CARES data as a baseline, improving trends in patient outcomes are projected, starting with 2022 data. There have been many successful resuscitations reported already, including two teens and several other relatively young individuals who are not normally considered at risk for cardiac arrest. In all of these cases, AEDs were used in the resuscitation efforts, with most involving law enforcement application prior to EMS arrival. A "pay-it-forward" campaign was also implemented by several agencies with existing devices. Those AEDs were placed in youth sports venues, daycares, churches, and other facilities within the agencies' communities. Several recipients also expressed gratitude for the devices from a personal perspective. "This is the difference between life and death," said Sheridan County Sheriff Heidi Visocan. "We're pretty remote. [Sheridan County] is 1,700 square miles with 3,600 people. Sometimes we're 45 miles from the hospital, so it's going to take the ambulance a while to get out there to us. If we can get out there and start initial lifesaving care, it's going to be a really good benefit to the community."

The broader ECVC system has also seen improvements. Critical Access Hospitals and larger PCI facilities have improved communication and coordination with EMS, and as a result, have seen more cardiac arrest survivors. STEMI and Stroke Alerts from the field are happening more frequently in an effort to accelerate patient care at hospitals and shorten times to thrombolytics and PCI. Having access to CARES allows EMS and hospital partners to track these patients across the continuum of care, from arrest to hospital disposition. "Getting feedback from EMS and finding out the patient's outcome is a real motivator for the officers," said Officer Jon Ogden, AED Program Manager for Bozeman Police Department.

Creating a statewide system of care in such a large, rural state has been a challenge. CARES is a critical resource to drive change and ultimately, improve outcomes from cardiac arrest in the state of Montana.

A law enforcement officer responds to an out-of-hospital cardiac arrest equipped with an AED.
Photo taken by Courtney Perry: © The Leona M. and Harry B. Helmsley Charitable Trust.

Right Place, Right Time

By Becka Neumiller, Nebraska CARES State Coordinator & Health Program Manager

Some people are just in the right place at the right time. That is true of Officer Markve of the Bellevue Police Department in Bellevue, Nebraska. Officer Markve received a Lifepak CR2 AED for his patrol vehicle as part of a $6.4 million dollar statewide grant awarded to The Nebraska Department of Health and Human Services from the Helmsley Charitable Trust to place AEDs in all first response law enforcement vehicles, and is putting his new equipment to good use. Since receiving the unit in June of 2021, Officer Markve has deployed his AED on three separate cardiac arrest victims. Two of those individuals survived their cardiac arrest, were released from the hospital with no deficits, and continue to enjoy their lives with loved ones. One of these survivors is Candi Rathe.

December 18th, 2021, was an ordinary day per Officer Markve. He remembers that it was close to the end of his shift, and although normally he would have been heading to the station to wrap up his work before going home, he decided to stay out on patrol. This decision would prove to be fortuitous.

As Officer Markve was patrolling, he heard the rescue tones drop for "CPR in progress". He and his coworker, Officer Andahl, both raced to the address from different parts of the city. When Markve pulled up to the house, he grabbed the AED out of his patrol car and went inside to find Andahl preforming CPR on 41-year-old Candi Rathe.

While Andahl continued CPR, Markve applied the AED to Candi. The AED indicated that defibrillation was advised, so Markve followed the prompts and delivered a shock. He and Andahl noticed that Rathe had agonal respirations after the shock and the two officers continued CPR. Moments later, Bellevue Fire and Rescue, an Advanced Life Support EMS service, arrived on scene and continued patient care. By the time EMS left the scene, Candi had ROSC (return of spontaneous circulation) and was taken to the nearest hospital, Nebraska Medicine-Bellevue Campus.

Candi has no memory from the day of her cardiac arrest so her partner, Travis Harrington, and daughter, Delaney Harrington, have helped fill in the gaps. Travis says that he woke up just before 5:00 am and when he returned to bed noticed that something was not right with Candi. "Her breathing was off and it was like she was having a seizure and then she just stopped breathing completely," says Travis. He and Delaney called 911 at 5:15 am, moved Candi from the bed to the floor, and started CPR immediately. Within four minutes, Officer Markve administered the AED shock.

Candi and her family are very eager to spread the message about how important the chain of survival is, as early recognition of cardiac arrest, high quality CPR, and AED use were all critical components to her survival. "Without CPR and the AED, I wouldn't be here," Rathe said. "Those machines are wonderful. They're lifesavers, for sure."

Officer Markve echoes Candi's sentiment. "She was the first person I ever saw saved on the scene," he said. "Just seeing that the machine works and that the family still has their loved one is why I will always take the extra three seconds to grab my AED, because I know now that they work!"

"Putting these devices in law enforcement vehicles and state parks will reach more Nebraskans in need, saving lives," says DHHS Chief Executive Officer Dannette R. Smith.

From left to right: Travis Harrington, Travis Harrington Jr., Delaney Harrington, Candi Rathe, Officer Robert Markve, and Officer Tyler Andahl.

The Florida Resuscitation Academy: To See Another Sunrise

By Thomas DiBernardo, Florida CARES State Coordinator, Florida Department of Health

In 2017, The Florida Department of Health provided a grant to fund a pilot resuscitation academy in an effort to improve out-of-hospital cardiac arrest resuscitation practices within the state. In preparation, Assistant Fire Chief Jorge Gonzalez and Battalion Chief Daniel Moran of Davie Fire Rescue attended the Resuscitation Academy Leadership Seminar in Seattle, Washington where they learned about the 10 Steps for Improving Survival from Cardiac Arrest. Topics included cardiac arrest data collection, telephone CPR and rapid dispatch, high performance CPR, AED and CPR training, and implementation of best practices and change management. Equipped with these resources, they partnered with Davie Fire Rescue's Medical Director, Dr. Peter Antevy, to host a local resuscitation academy in southern Florida, attended by more than 300 participants. The initial academy was overwhelmingly well-received and thus, the Florida Resuscitation Academy was created.

In June 2018, the state experienced a surge of support to expand the CARES program to any EMS agency wishing to join. As data is a crucial component in improving resuscitation efforts, it was only natural to couple the two efforts. The Florida EMS Trust Fund provides the funds for a dedicated CARES State Coordinator and the Florida EMS Matching Grant Program provided funds to cover the CARES state subscription fee as well as three Florida Resuscitation Academies.

During 2021, the Florida Resuscitation Academy continued to receive grant funding through the State of Florida's Rural Health Office to conduct five courses in rural areas of the state. The goal of these courses is to train attendees on all aspects of resuscitation. Lectures cover the importance of measurement via CARES data input and analysis, teach Telephone-CPR using the NHTSA CPR LifeLinks program, and demonstrate how to implement a "train-the-trainer" model for High-Performance CPR using an organized systematic approach known as "Pit Crew". The grant also provided funds to purchase both high-performance and basic manikins for First Responders and telecommunicators, allowing attendees to take these critical resources back to their respective agencies and call centers for training.

"It's the little things – saving a second here, shaving off two seconds there," says Becky Mathews, HP-CPR Instructor/Trainer, "I think a big piece of the RA is mindset change. Think about athletes – an Olympic skier knows how to go down the mountain, but they also have coaches. They have people who can break down their turns or the way they push off, which can make a huge difference over the length of a run. We're doing the same thing here. Everyone knows how to do CPR, but we can make little tweaks - cutting down on pauses or bagging more effectively - which make a big difference over the length of a resuscitation."

Today, the Florida Resuscitation Academy has completed over 10 resuscitation academies across a variety of regions – South Florida, the Space Coast, the Heartland, the Emerald Coast, and the Gulf Coast. Since its inception, more than 800 Fire, EMS, and Hospital providers across the state have attended one of the academies and are now better equipped to handle the challenges in improving resuscitation efforts.[6] In March 2022, the Florida Resuscitation Academy was named an RA Lighthouse, by the Resuscitation Academy in Seattle, Washington. Lighthouse communities serve as mentors to others, spread the RA message and create positive change. Lighthouses live the 10 Steps and are beacons to others. The hard work of the Florida Resuscitation Academy faculty has led to many survivors throughout Florida being given the chance "To See Another Sunrise."

[6] https://www.youtube.com/watch?v=2Ze3400uMok

Research Highlights

Compression-only CPR vs. CPR with Rescue Breathing for Pediatric Out-of-Hospital Cardiac Arrest

By Maryam Naim, MD, MSCE, Children's Hospital of Philadelphia

Since 2010 the American Heart Association has been recommending compression only CPR (CO-CPR) for lay rescuers of adult out-of-hospital cardiac arrest (OHCA). The impact of this effort on pediatric OHCA was unknown. Children experience more asphyxial arrests and therefore CPR with rescue breathing (RB-CPR) is the preferred modality for bystander CPR.

"Increasingly I was observing that children who had an OHCA were receiving CO-CPR and I wanted to know whether their outcomes were being impacted", explained Maryam Naim, lead author[7] "It was also possible that some age groups, like adolescents who have more shockable and primary cardiac events, would benefit from CO-CPR; however, age stratified analyses had not been previously performed."

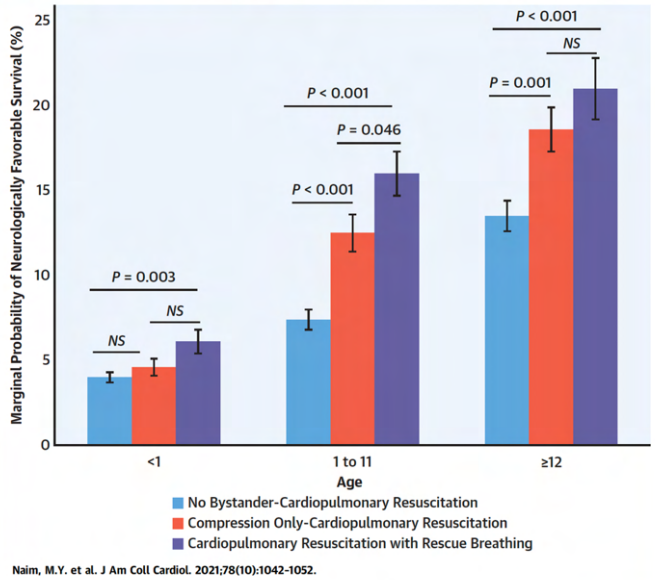
The investigators had previous experience using the CARES registry and were confident that these questions could be answered using CARES data. An analysis of the Cardiac Arrest Registry to Enhance Survival for non-traumatic pediatric OHCAs (≤18 years) from January 2013 through December 2018 was conducted. Age groups included infants (<1 year), children (1 to 11 years), and adolescents (≥12 years). The primary outcome was neurologically favorable survival at the time of hospital discharge, defined as a cerebral performance category (CPC) score of 1 or 2.

Of the 13,060 pediatric cardiac arrests captured in the CARES database, 46.5% received bystander CPR. In arrests where the type of bystander CPR was known, 45.3% received RB-CPR whereas 55.6% received CO-CPR (1% received CPR with ventilations only). Arrests were more common in infants, males, and White and Black children. The majority of arrests were unwitnessed, occurred in a home/residence, presented with a non-shockable rhythm, and had no AED use prior to EMS arrival. Over the 6-year period of the study, the rates of bystander CPR did not change, but there was a significant increase in the proportion of pediatric OHCA receiving CO-CPR. Bystander CPR was most commonly provided by a family member (71.7%), followed by lay person (21.9%), and lay person with medical training (6.4%). Lay person family members (CO-CPR: 54.8%) and lay persons (CO-CPR: 58.9%) were more likely to perform CO-CPR, whereas lay persons with medical training were more likely to perform RB-CPR (61.5%).

Neurologically favorable survival was observed in 8.6% of cardiac arrests. Over the 6-year study period, there was no change in neurologically favorable survival. OHCAs with RB-CPR and CO-CPR had better outcomes compared with NO-CPR (RB-CPR 13.4%, CO-CPR 12.2%, NO-CPR 5.8%, *p<0.001*). In multivariable analysis, RB-CPR (adjusted proportion: 12.0%, 95% CI: 10.7-13.2; adjusted OR: 2.16, 95% CI: 1.78-2.62) and CO-CPR (adjusted proportion: 9.7%, 95% CI: 8.7-10.7; adjusted OR: 1.61, 95% CI: 1.34-1.94) were both independently associated with neurologically favorable survival compared with NO-CPR (adjusted proportion: 6.8%, 95% CI: 6.2-7.4).

Neurologically favorable survival was observed in 4.6% of infants, 10.6% of children, and 16.5% adolescents. In infants, neurologically favorable survival was observed in 5.2% arrests with CO-CPR, 6.9% with RB-CPR, and 3.7% with NO-CPR; *p <0.001*. In multivariable analysis, RB-CPR was associated with neurologically favorable survival compared with NO-CPR (adjusted OR: 1.65, 95% CI: 1.19-2.30); however, CO-CPR was not associated with outcome. In children, neurologically

CENTRAL ILLUSTRATION Neurologically Favorable Survival and Cardiopulmonary Resuscitation Type in Infant, Children, and Adolescents



Naim, M.Y. et al. J Am Coll Cardiol. 2021;78(10):1042-1052.

Adjusted neurologically favorable survival and *P* values are from stratified logistic regression models (by age group) with neurologically favorable survival as the outcome variable and covariates year of arrest, sex, race/ethnicity, bystander-witnessed arrest, arrest location, shockable rhythm, AED used before EMS, and region of arrest. No adjustments for multiple testing were applied. **Blue bars** indicate NO-CPR; **red bars**, CO-CPR; and **purple bars**, RB-CPR. **Error bars** indicate 95% confidence intervals. CO-CPR = compression only-cardiopulmonary resuscitation; CPR = cardiopulmonary resuscitation; NO-CPR = no bystander-cardiopulmonary resuscitation; RB-CPR = cardiopulmonary resuscitation with rescue breathing.

[7] Naim MY, Griffis HM, Berg RA, Bradley RN, Burke RV, Markenson D, McNally BF, Nadkarni VM, Song L, Vellano K, Vetter V, Rossano JW. Compression-Only Versus Rescue-Breathing Cardiopulmonary Resuscitation After Pediatric Out-of-Hospital Cardiac Arrest. *J Am Coll Cardiol*. 78(10):1042-1052.

favorable survival was observed in 13.9% of arrests with CO-CPR, 17.3% with RB-CPR, and 6.8% with NO-CPR; *p <0.001*. In multivariable analysis, both RB-CPR and CO-CPR were associated with neurologically favorable survival compared to NO-CPR, and RB-CPR was associated with a higher odds of neurologically favorable survival compared to CO-CPR (adjusted OR: 2.73, 95% CI: 2.00-3.72, and adjusted OR: 1.94, 95% CI: 1.41-2.68, respectively). In adolescents, neurologically favorable survival was observed in 23.7% of arrests with CO-CPR, 25.7% with RB-CPR, and 10.3% with NO-CPR, *p <0.001*. In multivariable analysis, both RB-CPR and CO-CPR were associated with neurologically favorable survival compared to NO-CPR.

Overall, the results of this study support current guidelines that recommend RB-CPR for pediatric OHCA. These results also support the use of RB-CPR and CO-CPR in children and adolescents with pediatric OHCA. However, CO-CPR was not associated with neurologically favorable survival in infants, therefore RB-CPR should continue to be the recommended modality. CO-CPR is associated with increased bystander CPR rates and survival in adults who experience OHCA, and CO-CPR has been the focus of public health campaigns including statewide educational efforts, high school education, and dispatcher assisted CPR.

"CO-CPR is currently the most common type of bystander CPR in pediatric OHCA. While public health efforts emphasizing CO-CPR have improved overall outcomes after OHCA in adults, it is possible that they have disadvantaged the pediatric population, especially infants and young children. The results of this study have important implications on bystander CPR education and training, which should continue to emphasize RB-CPR for infants in cardiac arrest and teach lay rescuers how to perform RB-CPR," concluded Dr. Naim.

Understanding the Association of Survival, Length of Time on Scene, and Rate of Field Termination Using CARES Data

By Douglas F. Kupas, MD, EMT-P, FAEMS, Professor of Emergency Medicine, Geisinger Commonwealth School of Medicine
Christopher L. Berry, MD, Assistant Professor of Emergency Medicine, Geisinger Commonwealth School of Medicine

Resuscitation of out-of-hospital-cardiac arrest (OHCA) has undergone a gradual paradigm shift from a scoop-and-run approach, focused on rapid transport to the emergency department, to on-scene resuscitation with a focus of achieving return-of-spontaneous-circulation (ROSC) where the patient lies. Delivering high-quality cardiopulmonary resuscitation (CPR) is a skill that is physically demanding and requires teamwork and attention to detail, and this quality deteriorates dramatically when done while a patient is being carried to or transported in a vehicle. As with most culture shifts in medicine, change is a gradual process and focused on-scene resuscitation has not been uniformly applied across all systems. A great strength of the CARES dataset is the heterogeneity of the EMS programs that contribute, allowing a comparison of the culture of resuscitation implemented by each agency.

The challenge is how to quantify the resuscitation culture of an organization. To do this, our team evaluated 221,228 cases from the 380 CARES agencies with at least 100 cardiac arrest patients between 2013-2018 applying two different criteria: 1) average on-scene time an organization spends on OHCA patients and 2) the rate of field termination for an organization.[8] It was hypothesized that organizations that spent more time on-scene resuscitating patients, applying high quality CPR and appropriate interventions where the patient lies, would therefore have improved outcomes than an agency focused on rapid transport. It was further hypothesized that programs that spent time on scene resuscitating may ultimately terminate resuscitation utilizing validated field termination of resuscitation (FTOR) rules on scene rather than transport those patients whose resuscitation was ultimately unsuccessful. Therefore, two analyses were run separately, with one comparing agencies average on-scene times against their outcomes and another comparing agencies rates of FTOR and their outcomes. To allow for the statistical analysis, agencies were divided into quartiles (containing 95 agencies each) based on their average on-scene times or FTOR rates and comparisons were made between quartile one (the quartile of agencies with the shortest on scene times or the least amount of FTOR) and quartile four (the quartile of agencies with the longest on scene times and highest rates of FTOR).

FTOR rates were found to vary significantly among the agencies submitting to the CARES database, with some agencies not allowing for this practice at all and others terminating significantly more than 50% of their resuscitation attempts. Agencies may avoid FTOR due to a lack of compensation for care provided on scene with no transport or due to fear of leaving possible survivors behind. Figure 1 provides an unadjusted visualization of all four quartiles and their average rates of ROSC, survival to discharge and survival with good neurologic outcome. A trend is apparent: as rates of FTOR go up, the outcomes among OHCA victims appear to improve, suggesting that large numbers of potential survivors are not being left on scene due to the practice of FTOR. This is not to say that the act of field termination itself is a life-saving

[8] Berry CL, Olaf MF, Kupas DF, Berger A, Knorr AC; CARES Surveillance Group. EMS agencies with high rates of field termination of resuscitation and longer scene times also have high rates of survival. *Resuscitation*. 2021 Dec; 169:205-213.

procedure, rather, that these agencies are focused on resuscitation on scene, thereby achieving higher rates of ROSC in EMS care, and transporting the resuscitated potential survivors to a higher level of care. The agencies in Quartile 1 are noted to have on average inferior outcomes to those in the other three quartiles, suggesting that an agency with a resuscitation program that includes FTOR in their protocols is unlikely to have inferior outcomes due to this practice. There is likely a limit to this, however, as inspection of Quartile 4 suggests that some agencies who terminate a very large majority of their arrests, a resuscitation culture that might be best described as "defeatist", may in fact have worsened outcomes compared to others. In Quartile 4, there does appear to be an inflection point at approximately 50% field termination rate as being optimum in a high performing resuscitation program.

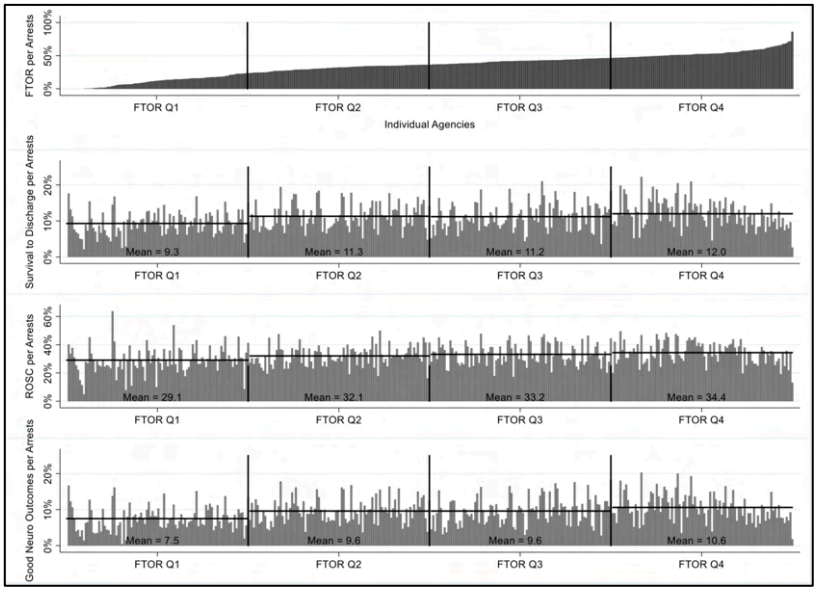


Figure 1. Unadjusted rates of FTOR and hospital death per arrest by agency.

Scene times were also noted to vary considerably among the study agencies. To complete this analysis, the study population who had undergone field termination of resuscitation was removed, owing to the fact that an on-scene time in this group is not well-defined as being spent on patient care, and the population of OHCA patients were only those who were transported by EMS. Figure 2 depicts the trend between the on-scene-time quartiles. There is a clear trend that agencies who spend more time on scene have improved rates of ROSC, survival to discharge and positive neurologic outcomes. All time spent on scene at a resuscitation is not equal. Besides the resuscitation itself, post ROSC care and extrication times also contribute. A strong resuscitation team may achieve ROSC quickly, but spend time on scene optimizing physiology prior to transport, leading to increased on scene time. This study is unable to account for what this time is being spent on. However, resuscitation while moving the patient as expediently as possible off the scene appears to yield inferior outcomes.

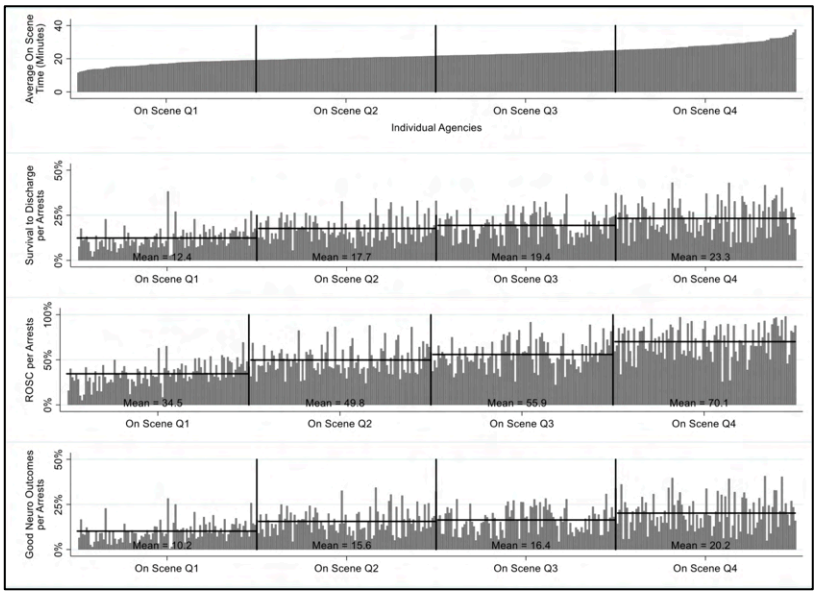
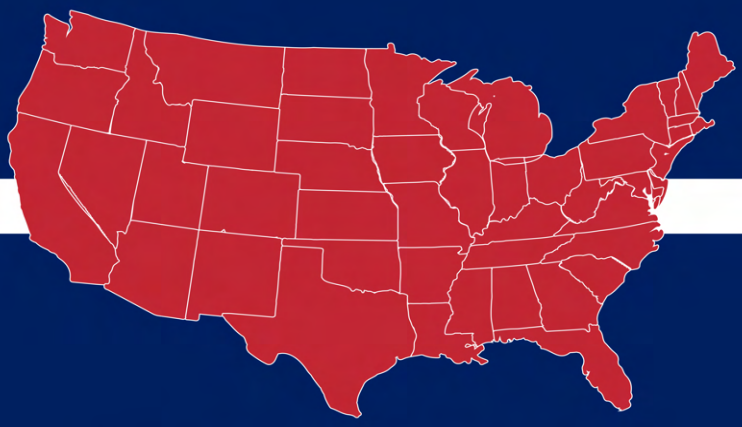


Figure 2. Unadjusted outcomes per non-FTOR arrest ordered by on scene time

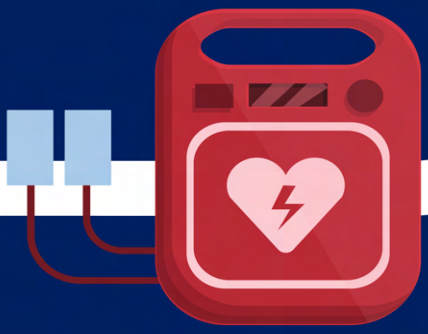
This study applying the CARES dataset adds to the growing body of literature that encourages on scene, high-quality resuscitation for the treatment of victims of OHCA prior to transport to yield improved patient outcomes. The intention of the study team is that when reviewing their resuscitation data, agency leadership may be able to apply this study when reviewing their agency's resuscitation program to further optimize care of this patient population. Our team does acknowledge that EMS agencies with prompt access to immediate extracorporeal cardiopulmonary resuscitation (ECPR) need to carefully determine which of their patients qualify for ECPR and should have minimal on-scene time and attention to transport to ECPR – understanding that the vast majority of OHCA patients are not close to ECPR care and only a small number of an EMS agency's cardiac arrest patients are candidates for ECPR. The existential question of the debate between "scoop and run" and "on scene resuscitation" for OHCA appears to, for now, be in favor of treating the patient where they lie.



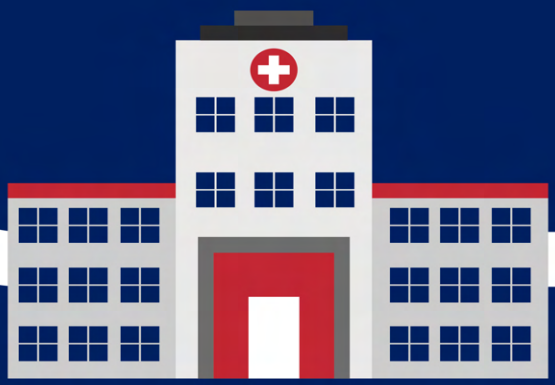
146,924 non-traumatic, worked OHCAs reported to CARES in 2021

40.2% of patients received bystander CPR

Median EMS response time: 7.1 minutes
27.1% of patients achieved sustained ROSC in the field



10.2% of patients who arrested in public had a bystander applied AED



24.7% of patients survived to hospital admission

44.1% of admitted patients received hypothermia care

9.1% of patients survived to hospital discharge

80.3% of discharged patients had a positive neurological outcome (CPC 1 or 2)

Incidence & Demographics

2021 Dataset and Incidence of OHCA Events

This report describes CARES data from the most recent calendar year, January 1 to December 31, 2021. CARES requires that an EMS Agency enter at least one complete calendar year of data and meet a patient lost to follow-up threshold of less than 1% to be included in the Annual National Report. The CARES 2021 National Reports can be viewed at: https://mycares.net/sitepages/reports2021.jsp.

Descriptive statistics in this report are presented as frequencies or proportions for categorical variables, and median and interquartile ranges for continuous variables. Comparison of proportions were conducted using the chi-square test.

The 2021 dataset includes 1,944 EMS Agencies and 2,194 Hospitals, and represents a population of 159.2 million, approximately 48% of the U.S. population. In 2021, 146,924 OHCA events were reported to CARES. The crude incidence of non-traumatic, worked arrests was 92.3 per 100,000, slightly higher than the incidence rate of 88.8 per 100,000 observed in 2020, and significantly greater than the average incidence rate observed pre-COVID (approximately 75 per 100,000). Using 2020 census data to extrapolate to the U.S. population[9], CARES estimates that there were approximately 305,800 EMS-treated, non-traumatic OHCAs in the United States last year.

Demographics

In 2021, CARES patients were predominately male (62.5%). Of the reported OHCA events, 97.6% (n=143,284) were adults and 2.4% (n=3,606) were children, 18 years and younger. The median age of OHCA patients was 64.0 years (mean: 62.0; SD: 19.1). The age distribution varied significantly across the sexes (Figure 2), with females having a higher median age of arrest (66.0 vs 63.0 years, p<.0001).

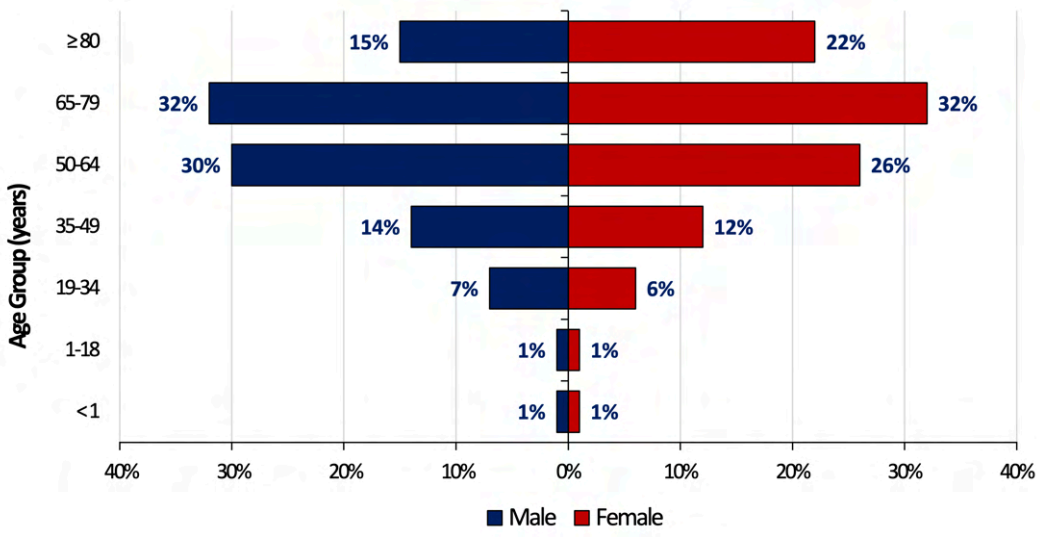


Figure 2. Age distribution of OHCA events.

[9] Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2020 Source: U.S. Census Bureau, Population Division.

Etiology

In alignment with the most recent ILCOR guidelines[3], CARES requires that all EMS-treated, non-traumatic cardiac arrests be entered into the registry. The etiology of arrest is identified by field providers and recorded in the patient care record. Per the Utstein guidelines, an arrest is presumed to be of cardiac etiology unless it is clearly documented otherwise.

In 2021, 82.0% of adult (>18 years of age) OHCAs were presumed to be of a cardiac cause. Other causes of adult OHCA were: respiratory/asphyxia (9.3%), drug overdose (6.4%), exsanguination/hemorrhage (0.8%), drowning/submersion (0.5%), and other medical (1.0%) (Figure 3).

The etiology of arrest for pediatric patients (≤18 years of age) differed substantially from that of adults. In 2021, 41.5% of pediatric arrests were presumed to be of a cardiac etiology. Other causes of pediatric OHCA were: respiratory/asphyxia (38.2%), drowning/submersion (8.8%), drug overdose (5.7%), SIDS/SUID (3.4%), and other medical (2.4%) (Figure 4).

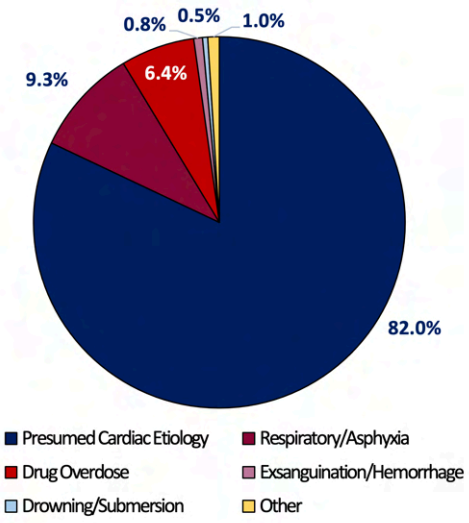


Figure 3. Etiology of arrest for adults.

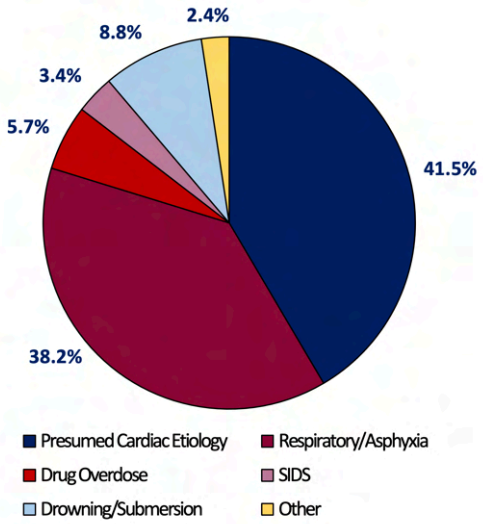


Figure 4. Etiology of arrest for pediatric patients.

Figure 5 further highlights the relationship between arrest etiology and patient age. Presumed cardiac cause was the most predominant etiology for all age groups, with the proportion of arrests attributable to this cause increasing with patient age. However, pediatric patients were much more likely than adults to experience an arrest due to respiratory cause. Drug overdose accounted for 36.1% of arrests in the 19-34 age group and 17.7% of arrests in the 35-49 age group, highlighting the impact of the current opioid epidemic in the United States.

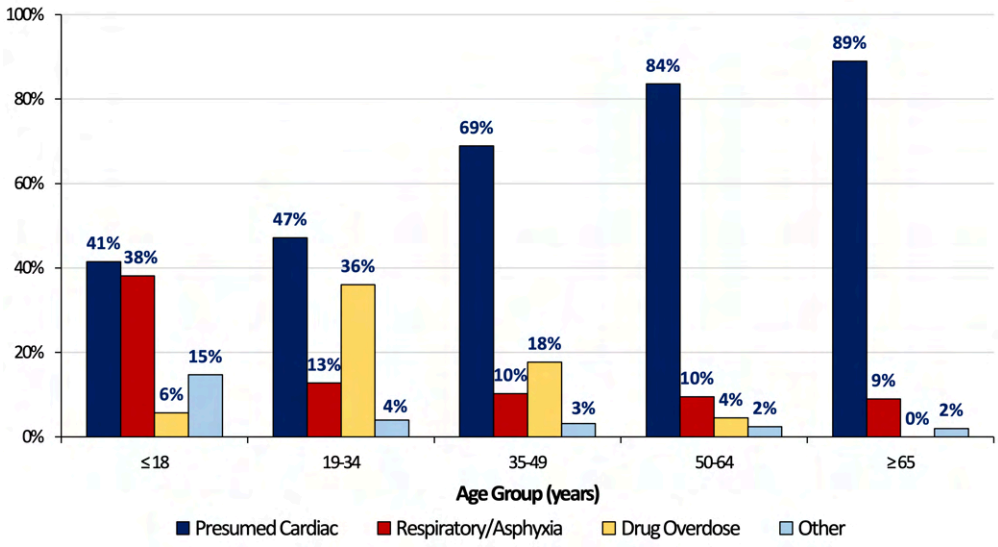


Figure 5. Etiology of arrest by age group.

Location of Arrest

The most common place for an OHCA to occur is in a residential setting, with 73.7% of events occurring in a home. Other common arrest locations were nursing home (10.0%), public or commercial building (6.7%), street or highway (4.0%), and healthcare facility (3.2%) (Figure 6).

The location of an OHCA is highly correlated with bystander intervention and patient outcome. In comparison to residential arrests, patients who arrested in a public setting were far more likely to have a bystander witnessed event and receive bystander CPR prior to EMS arrival (Figure 7). Patient outcomes were also significantly different across incident locations, with public arrests having a 2.6-fold rate of survival to hospital discharge compared to residential arrests (19.0% vs 7.8%, respectively; p< .0001).

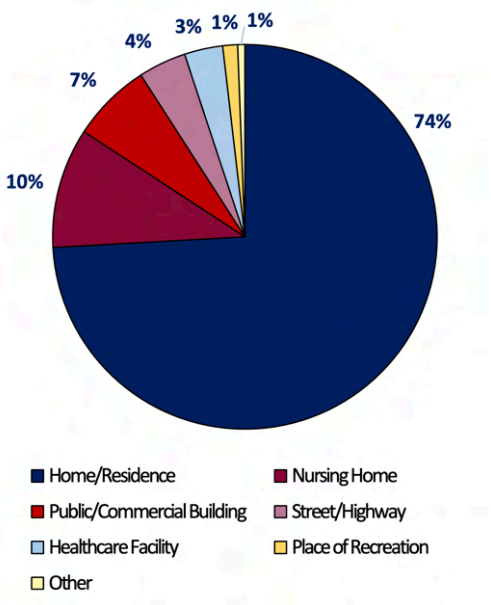


Figure 6. Location of arrest.

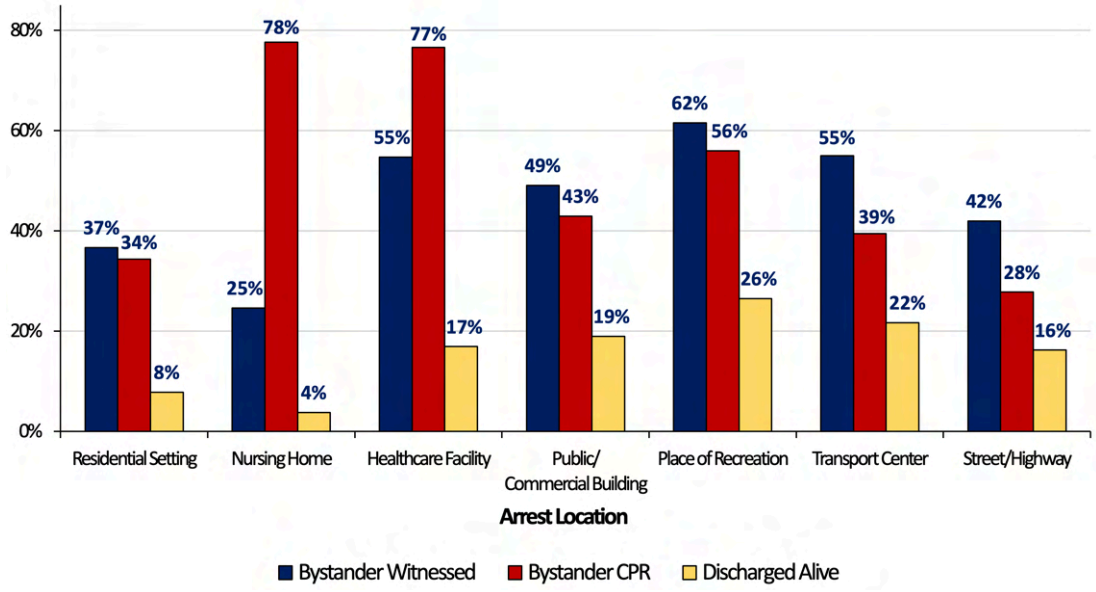


Figure 7. Percentage of events that are bystander witnessed, receive bystander CPR, and survive to hospital discharge by arrest location.

Witness Status

Arrest witness status has significant implications for patient outcomes, as witnessed arrests have more opportunity for bystander intervention and early delivery of care.

Approximately half of arrests were unwitnessed (50.4%), while 37.5% were bystander witnessed and 12.1% were witnessed by a 911 Responder (Figure 8). Patients with a bystander witnessed arrest were more than 3 times as likely to survive their event compared with unwitnessed arrests (13.5% vs 4.3%, respectively; p<.0001), while patients with a 911 Responder witnessed arrest were approximately 4 times as likely to survive compared with unwitnessed arrests (15.9% vs 4.3%, respectively; p<.0001).

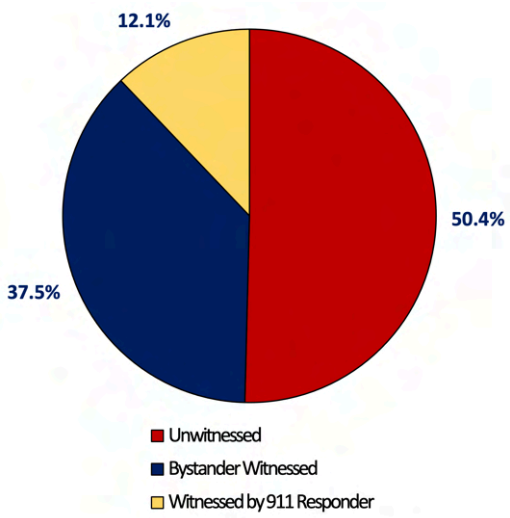


Figure 8. Arrest witness status.

Initial Rhythm

When the cardiac rhythm is first monitored after OHCA, a patient may present in a shockable rhythm (ventricular fibrillation or ventricular tachycardia) or non-shockable rhythm (asystole or idioventricular/pulseless electrical activity [PEA]). Treatment and prognosis depend on presenting rhythm, with better survival after OHCA among patients with a shockable rhythm (26.0% vs 5.8%, p<.0001).

16.4% of patients presented with an initial shockable rhythm of ventricular fibrillation (VF) or ventricular tachycardia (VT), while 83.6% of patients presented in an unshockable rhythm, with asystole being the most common (52.8%). Presenting rhythm differed markedly by arrest witness status, with bystander witnessed patients being much more likely to present in a shockable rhythm than unwitnessed patients (25.9% vs 9.3%, respectively; p<.0001) (Figure 9).

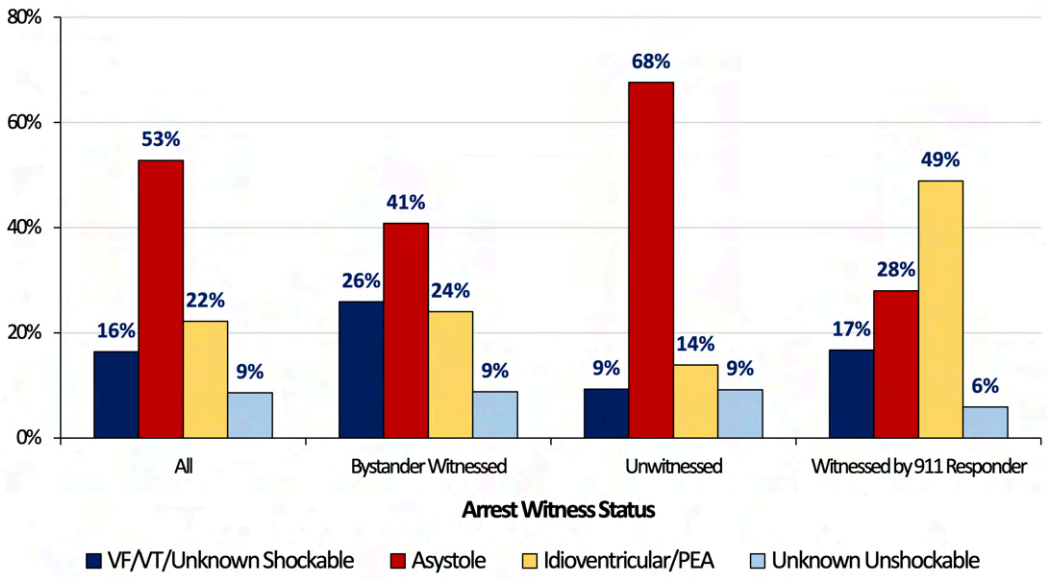


Figure 9. Presenting arrest rhythm by arrest witness status.

01

Activation of Emergency System

02

Early CPR

03

Early Defibrillation

04

Rapid Delivery of EMS Care

Chain of Survival

The chain of survival refers to a series of actions intended to maximize the chances of survival following cardiac arrest. The six links in the chain of survival are activation of the emergency response system, early CPR, early defibrillation, rapid delivery of EMS care, post-resuscitative care, and recovery. For every minute of cardiac arrest without CPR or defibrillation, a patient's chance of survival falls by 7-10%[10]. This means that the community and bystander response are integral to survival from OHCA.

Activation of the emergency response system

The first step in the chain of survival is recognition of cardiac arrest and activation of the emergency response system by calling 911. The next crucial time period is the interval between call receipt at the dispatch center to arrival on scene, or "response time". The distribution of First Responder and EMS response times are presented in Figure 10.

Response and treatment times are supplemental elements in CARES; however, participants are encouraged to measure response times in order to identify local opportunities for improvement. Records with missing response times (15.0%) as well as those that were witnessed by a 911 Responder (12.1%), have been excluded from response time analyses.

In 2021, median response time by First Responders was 6.3 minutes (IQR: 5.0 - 8.5 minutes) and median response time by EMS was 7.4 minutes (IQR: 5.4 - 10.3 minutes). First Responders arrived on scene in ≤ 5 minutes for 27.8% of arrests, while EMS arrived on scene in ≤ 9 minutes for 64.8% of arrests.

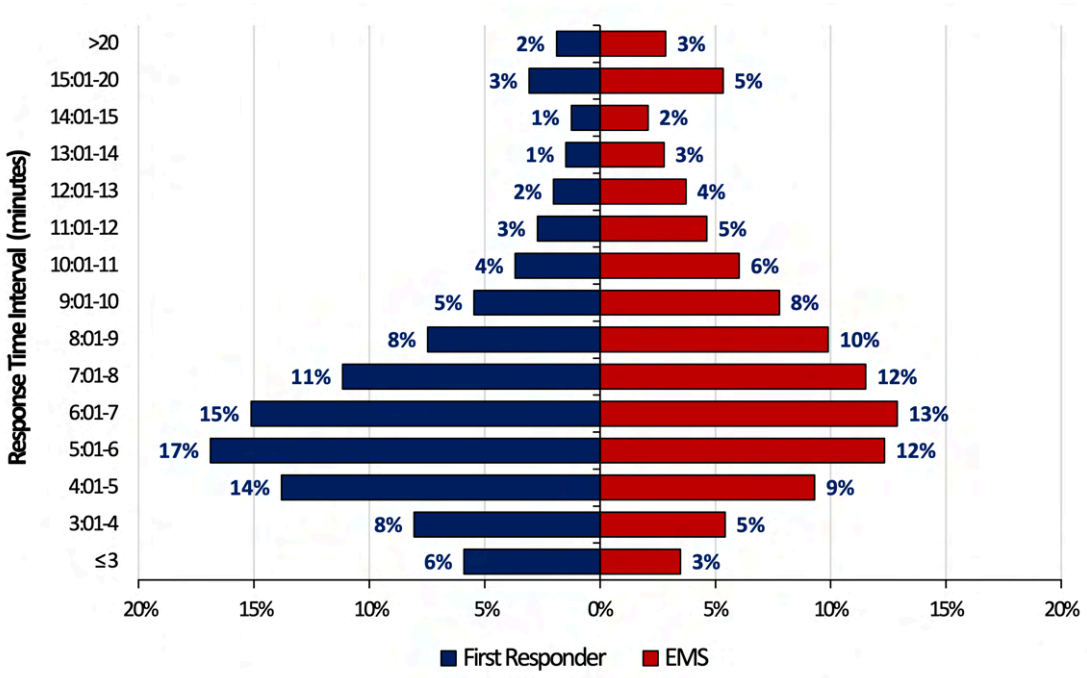


Figure 10. Distribution of First Responder and EMS response times (time interval from 911 call to arrival on scene).

[10] Larsen MP, Eisenberg MS, Cummins RO, Hallstrom AP. Predicting survival from out-of-hospital cardiac arrest: a graphic model. *Ann Emerg Med*. 22:1652–1658.

Figure 11 is a bivariate analysis of survival to hospital discharge rate by EMS response time (measured from call receipt at dispatch center to arrival of the ambulance at the scene) for all OHCA patients as well as three subsets: bystander witnessed, bystander witnessed VF/VT (Utstein), and unwitnessed. Patients with a witnessed VF/VT arrest experienced a significant decrease in survival with increasing EMS response time. In contrast, response time had little effect on survival among unwitnessed arrests.

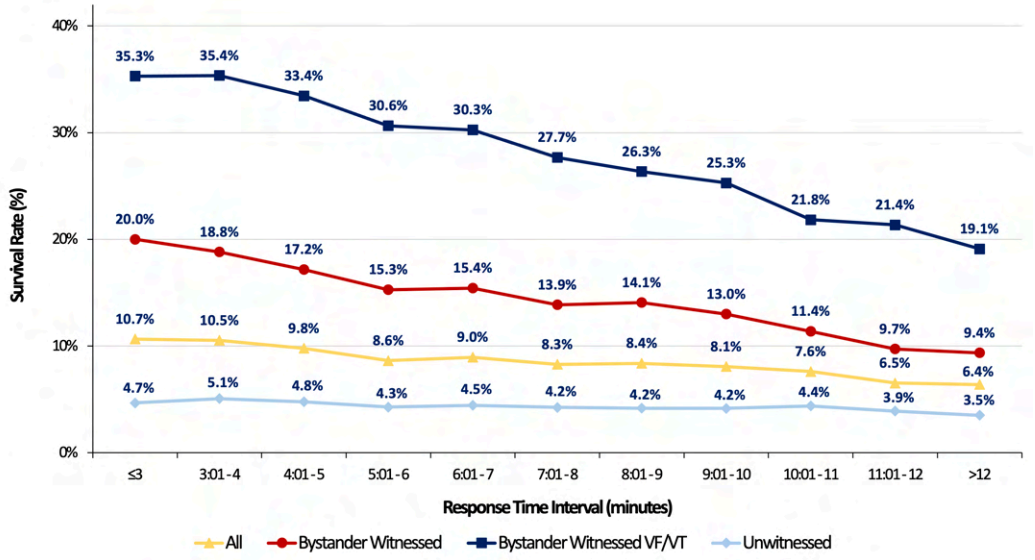


Figure 11. Survival rate by EMS response time and arrest witness status.

Figure 12 illustrates the interdependence between the links in the chain of survival, by highlighting how rapid 911 response and bystander CPR (bCPR) work in tandem to improve patient survival. Bystander CPR helps provide critical and timely intervention while 911 vehicles are in transit to the scene. By comparing the same patient subgroups in Figure 11 and Figure 12, one can see how survival is elevated when bystander CPR is performed.

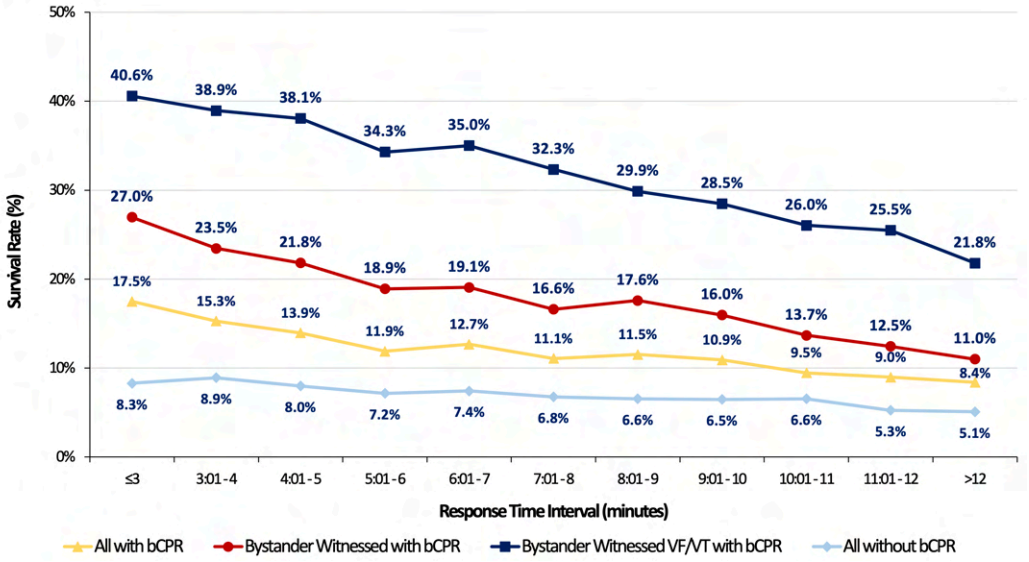


Figure 12. Survival rate by EMS response time and arrest witness status, among patients who received bystander CPR.

Put the heel of your hand on the center of the chest. Put your other hand on top of that hand. With your arms straight, push down hard and fast with the heels of your hands. I'll count with you…

Early CPR

One of the critical interventions to achieving successful resuscitation is early CPR. If CPR is started before an ambulance arrives, the patient's chances of survival dramatically increase. In 2021, bystander CPR was initiated on 40.2% of CARES patients. Of note, CARES excludes 911 Responder witnessed events as well as those that occurred in a nursing home or healthcare facility from our bystander CPR rate, as these are scenarios where we would expect CPR to be performed by a trained medical provider.

Bystander CPR provision was strongly correlated with arrest witness status (Figure 13). Bystander CPR was initiated after 48.1% of bystander witnessed events, compared with 34.0% of unwitnessed events (p<.0001).

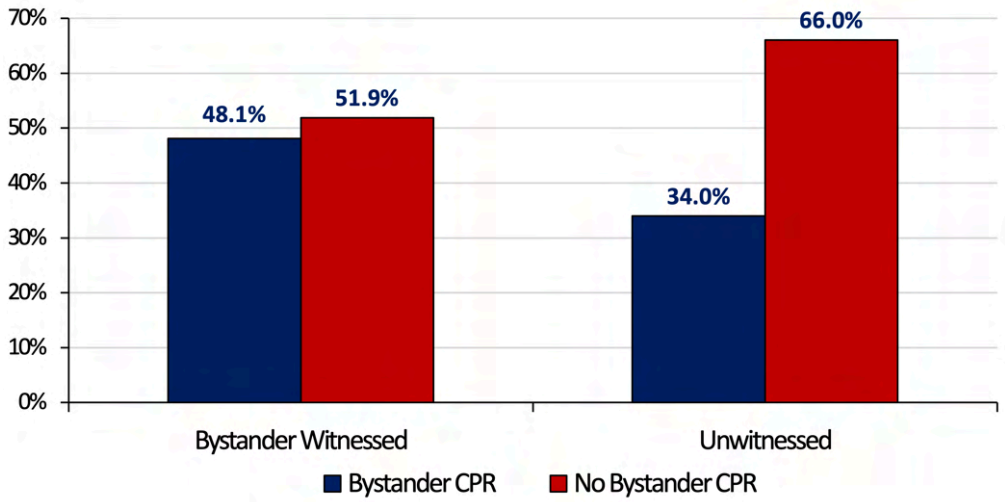


Figure 13. Bystander CPR provision by arrest witness status.

Return of spontaneous circulation (ROSC) in the field, survival to hospital admission, and survival to hospital discharge were all strongly associated with receipt of bystander CPR (Figure 14). The survival to discharge rate for patients receiving bystander CPR (11.2%) was significantly (p<.0001) higher than that of patients who did not receive bystander CPR (6.7%).

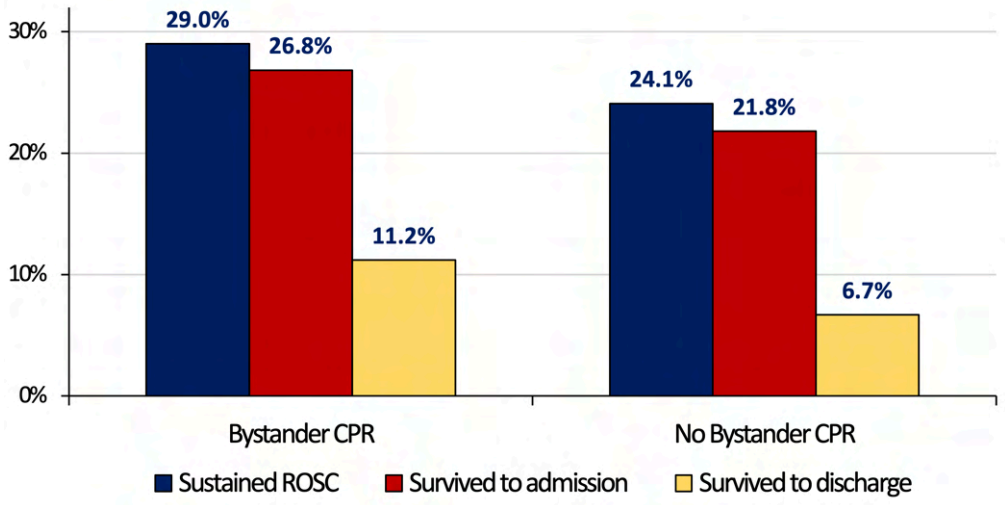


Figure 14. Unadjusted survival outcomes after bystander CPR.

Early Defibrillation

More than 15% of OHCAs occur in a public location; therefore, public access AEDs and community training have a large role to play in early defibrillation. However, the number of patients who have an AED applied by a bystander remains low, occurring after only 10.2% of public arrests.

In 2021, 28.7% (n=42,198) of CARES patients were defibrillated in the field. The proportion of patients first defibrillated by a bystander was 4.6%, whereas 19.1% and 76.3% were first defibrillated by a first responder or EMS personnel, respectively.

Reducing delays to defibrillation leads to better outcomes for patients in a shockable rhythm. Unadjusted outcomes for this subset of patients vary according to who performed the first defibrillation (Figure 15). The proportion of OHCA patients surviving to hospital discharge when first defibrillated by a bystander with an AED was 41%, compared with 24% of patients first shocked by a first responder and 25% of patients first shocked by responding EMS personnel.

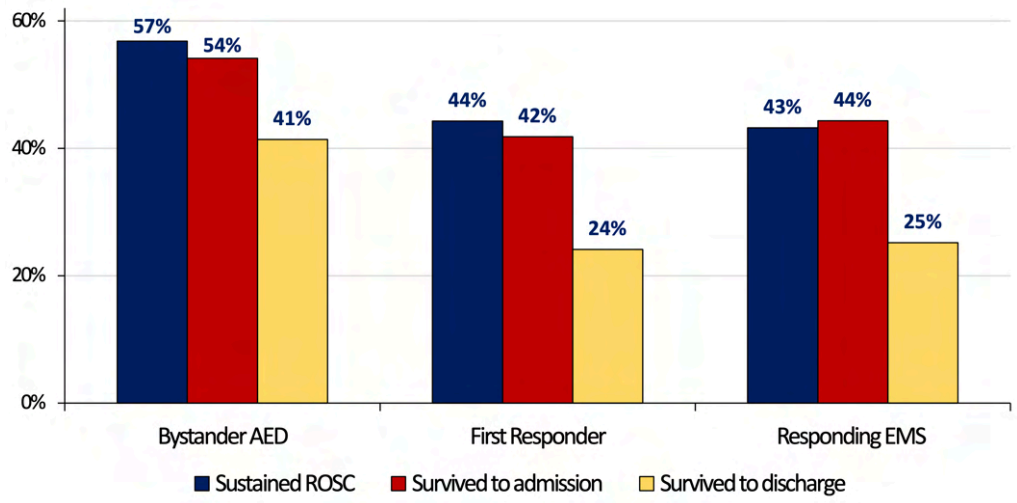


Figure 15. Unadjusted survival outcomes by who performed first defibrillation in the population with a shockable presenting rhythm.

Survival Outcomes

Patient Outcomes

On the basis of local EMS agency protocols, 42.4% of patients were pronounced on scene after resuscitative efforts were terminated in the pre-hospital setting (Figure 16). A successful attempt at resuscitation in the field is often defined by a patient's return of spontaneous circulation (ROSC). In 2021, sustained ROSC (20 consecutive minutes of ROSC, or present at transfer of care to a receiving hospital) was achieved by 27.1% of CARES patients.

The rate of survival to hospital admission was 24.7% (ED outcome missing for 269 cases; 0.2%), and the rate of survival to hospital discharge was 9.1% (hospital outcome missing for 305 cases; 0.21%). A majority of patients who were discharged alive had a neurologically favorable outcome, a Cerebral Performance Category (CPC) score of 1 or 2 (Table 3).

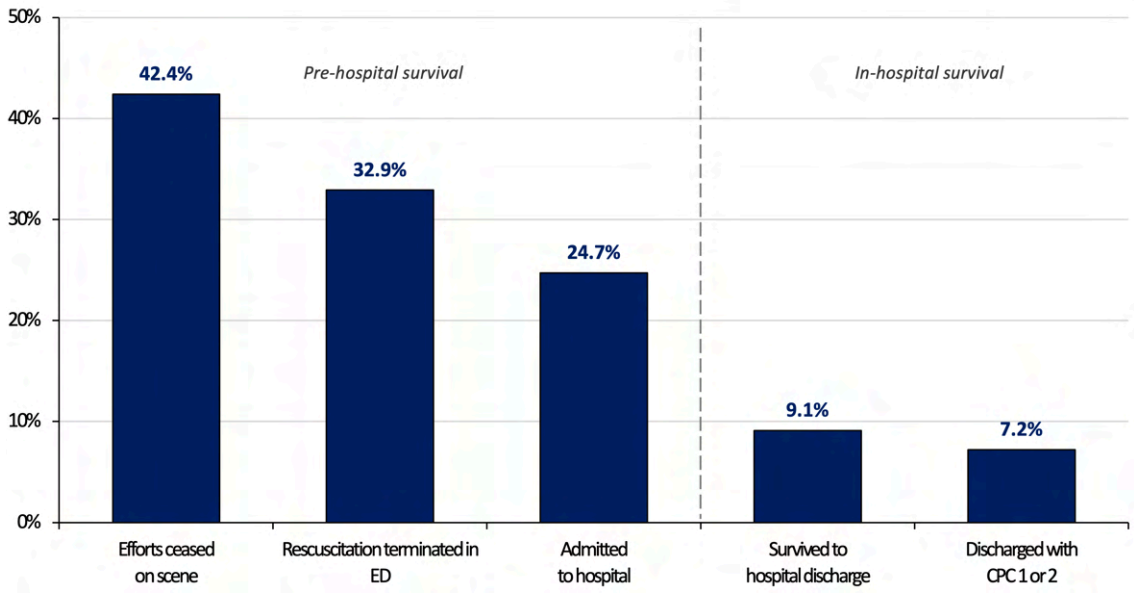


Figure 16. Unadjusted pre-hospital and in-hospital OHCA patient outcomes.

Table 3. Cerebral Performance Category (CPC) scores

CPC Score	Description
CPC 1	Good Cerebral Performance Conscious, alert, able to work and lead a normal life.
CPC 2	Moderate Cerebral Disability Conscious and able to function independently (dress, travel, prepare food), but may have hemiplegia, seizures, or permanent memory or mental changes.
CPC 3	Severe Cerebral Disability Conscious, dependent on others for daily support because of impaired brain function (in an institution or at home with exceptional family effort).
CPC 4	Coma, Vegetative State Not conscious. Unaware of surroundings, no cognition. No verbal or psychological interactions with environment.
CPC 5	Death

Arrest Characteristics and Outcomes

Survival outcomes differed markedly across etiology, presenting rhythm, and witness status categories.

Patients with an arrest of presumed cardiac etiology had an unadjusted survival rate to hospital discharge of 8.2%. Survival among patients with an arrest caused by a respiratory mechanism or drowning was slightly higher (11.3 and 12.2%, respectively), whereas patients with an overdose-related arrest had a survival rate of 18.4%. Survival was lowest among patients with an arrest due to exsanguination or hemorrhage (3.2%) (Figure 17).

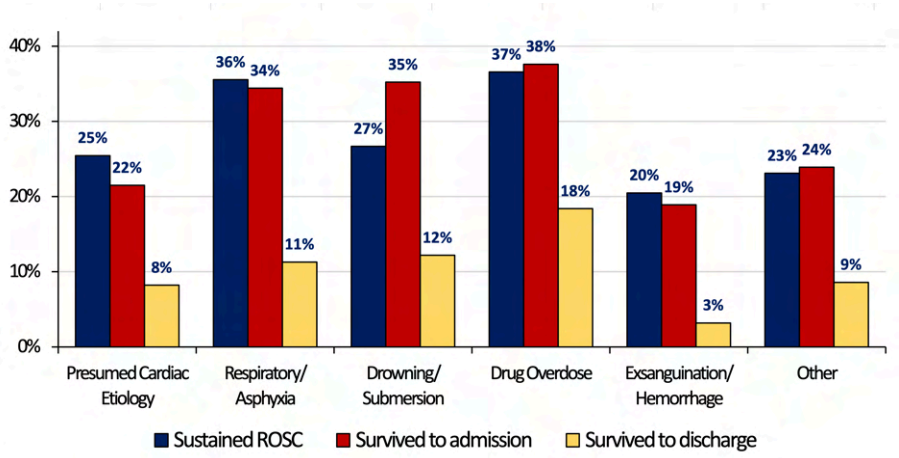


Figure 17. Unadjusted survival outcomes by arrest etiology.

Patients that present with an initial shockable rhythm of ventricular fibrillation (VF) or ventricular tachycardia (VT) have a much higher chance of survival than patients who present with a non-shockable rhythm such as asystole or pulseless electrical activity (PEA) (Figure 18). Patients who presented in a shockable rhythm had a survival to hospital admission rate of 44.5%, compared with 32.1% for those in PEA and 14.4% for those in asystole. Similarly, patients presenting in a shockable rhythm had a greater chance of being discharged alive (26.0%), compared with 10% of patients presenting in PEA and 2.3% of patients in asystole.

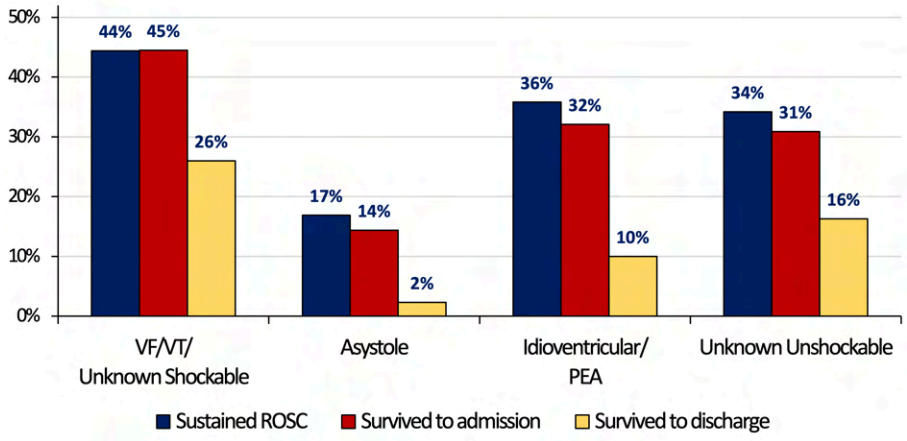


Figure 18. Unadjusted survival outcomes by presenting arrest rhythm.

Arrest witness status also has a significant impact on patient outcomes, as witnessed arrests have more opportunity for bystander intervention and early delivery of care. OHCA patients with a 911 Responder witnessed arrest had the highest chance of survival to hospital discharge (15.9%), followed closely by those with a bystander witnessed arrest (13.5%). In contrast, unwitnessed events had a survival rate of 4.3% (Figure 19).

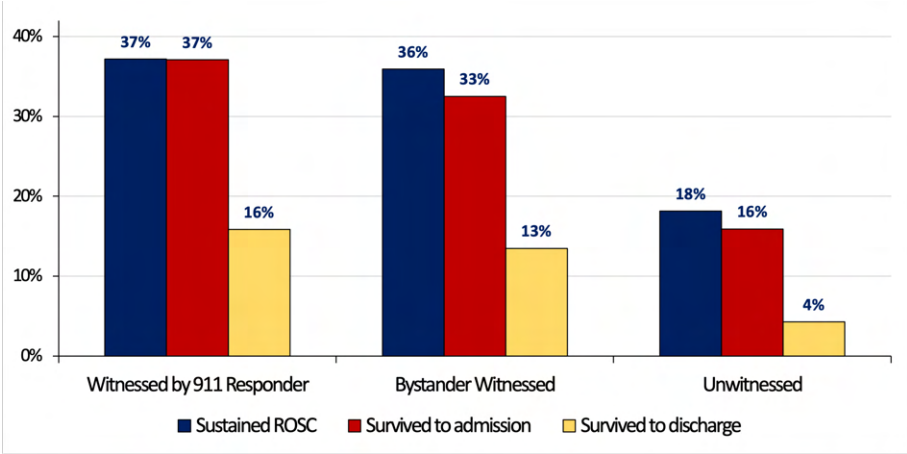


Figure 19. Unadjusted survival outcomes by arrest witness status.

Utstein Survival

The Utstein template was developed by international resuscitation experts to promote uniform reporting guidelines for clinical variables and patient outcomes. These guidelines define core data fields to ensure consistency in terminology and make recommendations on the data elements to be recorded for each OHCA event.

Patients who have a bystander witnessed OHCA and present in a shockable rhythm are the most likely to survive their arrest, and are referred to as the "Utstein" subgroup. This subset of arrests is an important measure of system efficacy, allowing for comparison of patient outcomes between systems and time periods, despite the wide variation of cardiac arrest circumstances and patient characteristics.

Figure 20 shows the National CARES Utstein Survival Report for 2021. This report stratifies arrests by witness status and presenting rhythm. In 2021, the survival to hospital discharge rate for the Utstein subgroup was 29.0%. Utstein bystander patients (arrest witnessed by a bystander, presented in a shockable rhythm, and received some bystander intervention [CPR and/or AED application]) had a survival rate of 32.5%.

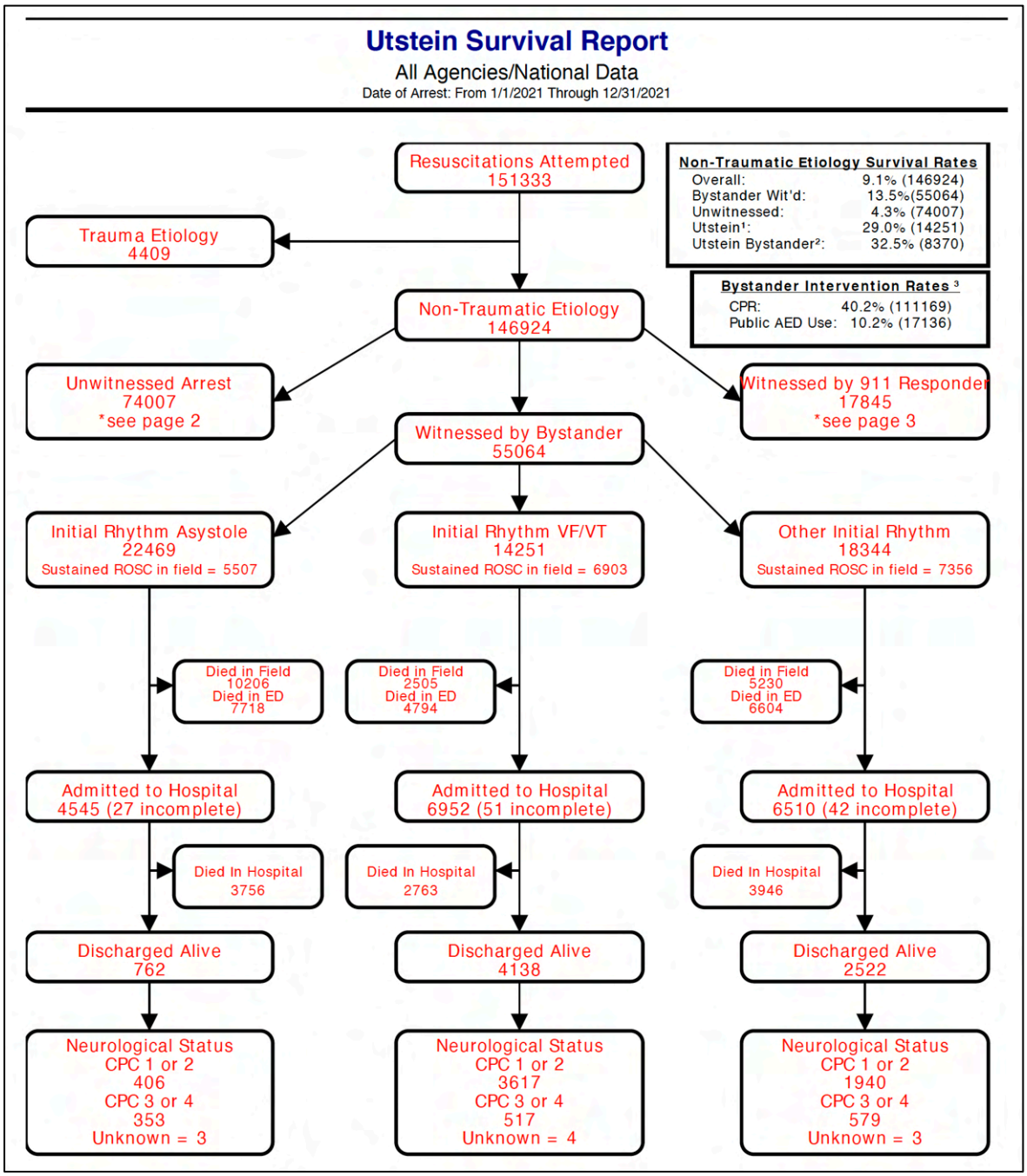


Figure 20. 2021 CARES Non-Traumatic Etiology Utstein Survival Report.

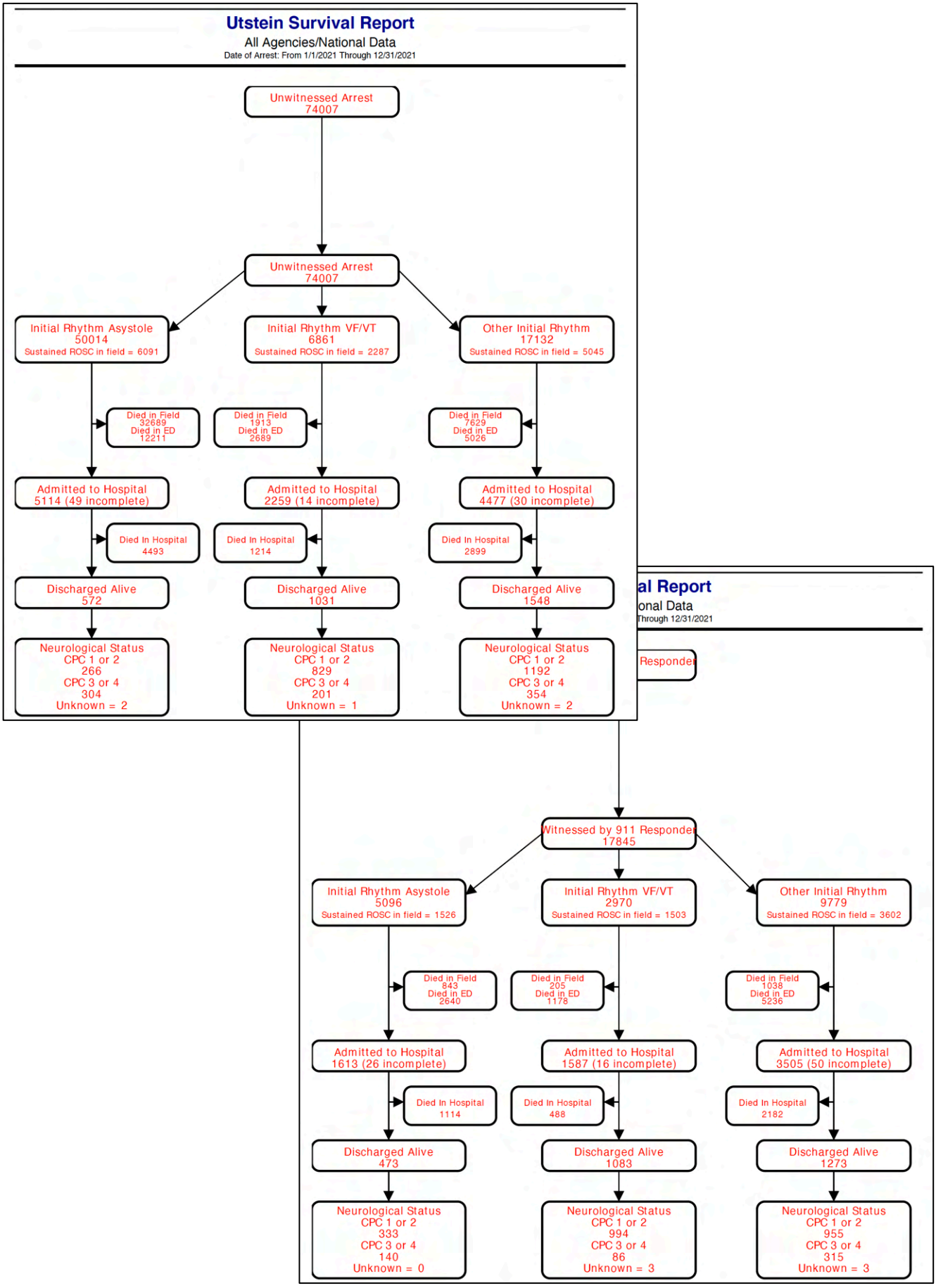


Figure 20. 2021 CARES Non-Traumatic Etiology Utstein Survival Report.


Pre Stent
RCA

Hospital Survival

The CARES Hospital Survival Report allows receiving centers to view summary metrics for their patient population. The report follows a flow diagram format, categorizing arrests by sustained ROSC in the field, initial rhythm, and patient outcome, and also allows for filtering of patients by whether they were transported by EMS or transferred from another acute care facility. Figure 21 shows the National CARES Hospital Survival Report for 2021.

Among all patients transported to a hospital, the survival to admission rate was 42.9% and the survival to discharge rate was 15.8%. Survival to hospital discharge was substantially higher among those who achieved sustained ROSC in the field (31.0%) compared with those who did not (2.6%), and among those who were transferred from another facility (42.1%) compared with patients who were transported directly by EMS (14.6%).

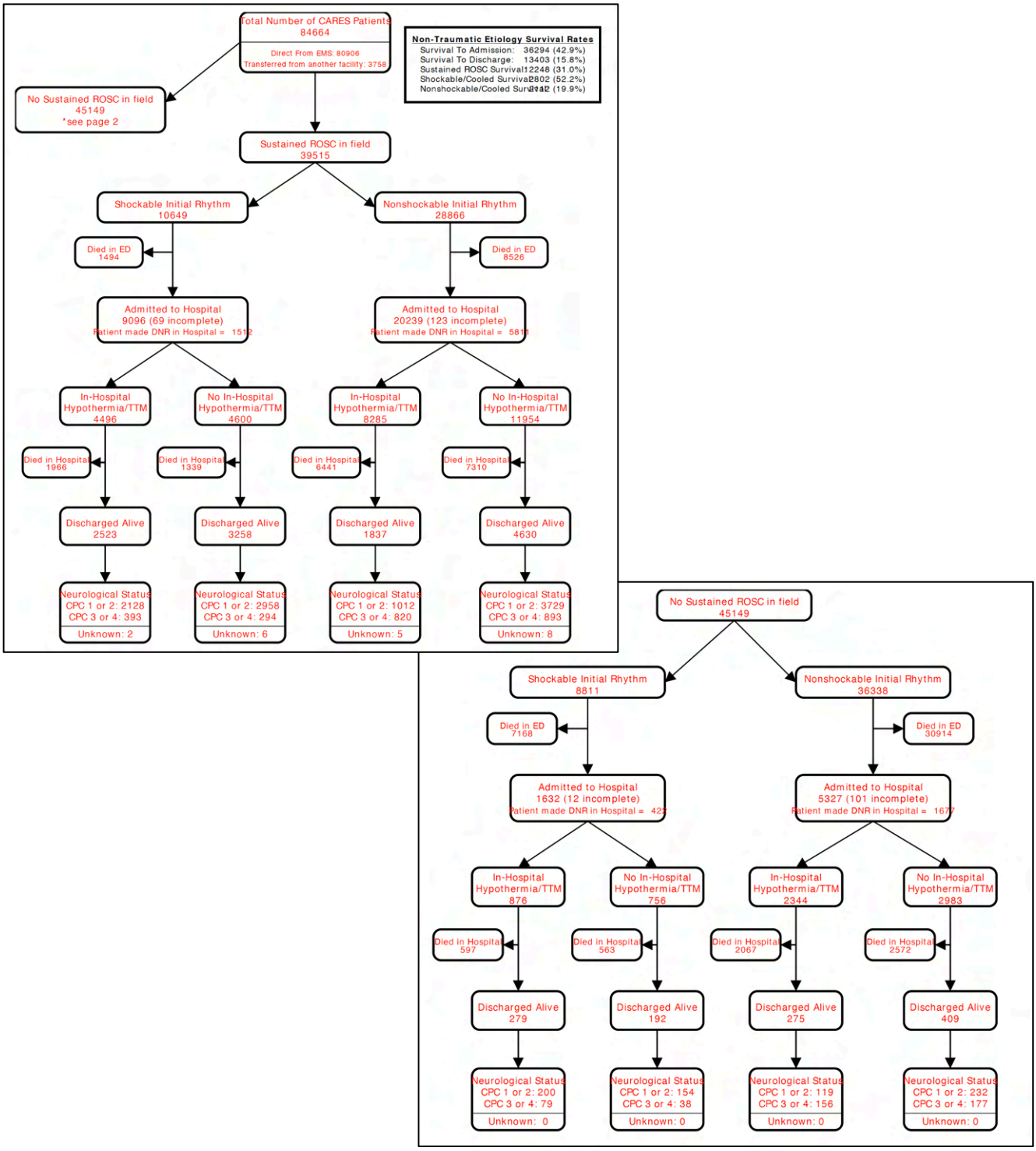


Figure 21. 2021 CARES Non-Traumatic Etiology Hospital Survival Report.

Regional Variation in OHCA Outcomes

There is marked regional variation in OHCA patient outcomes and bystander intervention rates. The diversity of CARES communities allows for comparison of system performance and outcome metrics. The figures below compare overall survival rates (Figure 22), Utstein survival rates (Figure 23), and bystander CPR rates (Figure 24) among the 175 EMS agencies with ≥200 CARES cases in 2021. These figures highlight the significant variability among participating agencies (ranges: overall survival 2.4–17.9% (more than 7-fold difference); Utstein survival 5.0–52.6% (more than 10-fold difference); bystander CPR 4.2–78.3% (more than 18-fold difference)). The bars in each figure represent communities with an underlying population ranging from 100,000 to over 2 million. The red dotted line denotes the national average for benchmarking purposes (overall survival: 9.1%; Utstein survival: 29.0%; bystander CPR: 40.2%), while the grey vertical lines indicate quartile cut points.

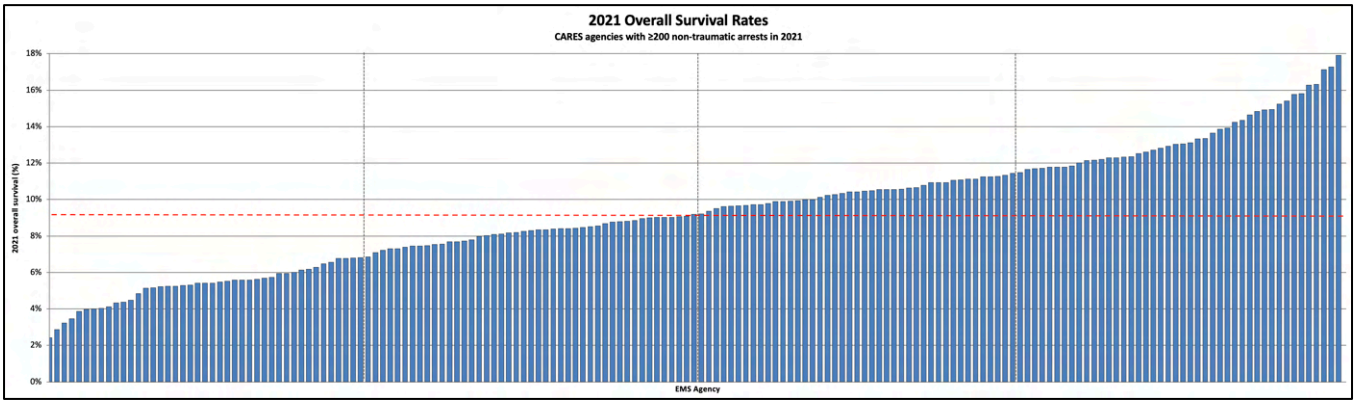


Figure 22. Variability in overall survival rates, among EMS agencies with ≥200 CARES cases in 2021.

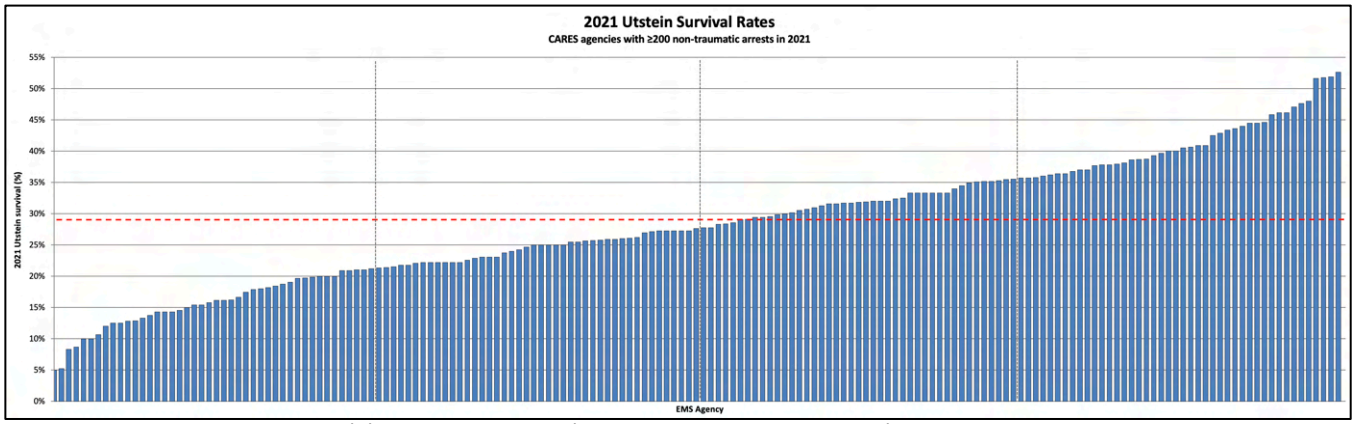


Figure 23. Variability in Utstein survival rates, among EMS agencies with ≥200 CARES cases in 2021.

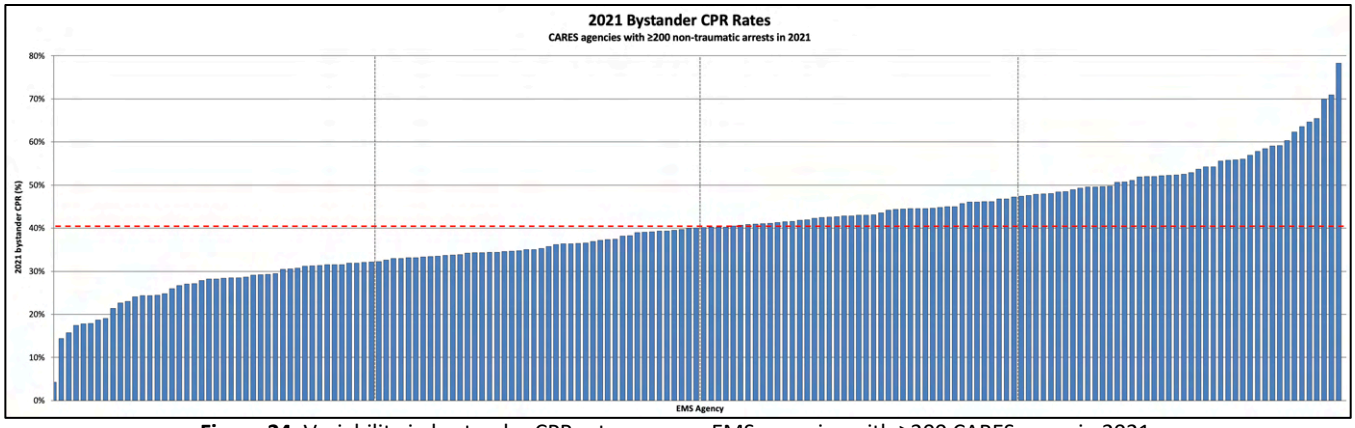


Figure 24. Variability in bystander CPR rates, among EMS agencies with ≥200 CARES cases in 2021.

Public Reporting of State Aggregate Metrics

Survival after out-of-hospital cardiac arrest varies between regions in the United States. With the growing number of CARES state participants, there is a unique opportunity to present aggregate metrics by state to better understand OHCA incidence, survival outcomes, and bystander intervention rates nationwide. The table below shows aggregate metrics for state participants that had at least 50% population catchment in 2021. 18 states and the District of Columbia voluntarily agreed to participate in reporting these metrics.

The included states have a wide range of both population catchment (606,347 to over 33 million) as well as incidence rate (44.2–135.5 per 100,000; 3-fold difference). There was also marked variability in community interventions, with bystander CPR rates ranging from 25.8–72.0% (an almost 3-fold difference) and public AED use rates ranging from 3.6–16.3% (a more than 4-fold difference), as well as patient outcomes (overall survival: 4.6–14.6%; Utstein survival: 22.8–37.9%).

Table 4. Public Reporting of State Aggregate Metrics, 2021

	OHCA Incidence					Non-Traumatic Etiology Survival Rates		Bystander Intervention Rates	
	CARES Cases Reported	2021 CARES Population Catchment	2021 Total State Population	% Population Covered	Incidence Rate (per 100,000)	Overall Survival to Hospital Discharge (%)	Utstein Survival (%)	CPR (%)	Public AED Use (%)
National	**146,924**	**159,252,560**	**331,449,281**	48.0%	92.3	9.1	29.0	40.2	10.2
State									
Alaska	563	606,374	733,391	82.7%	92.8	13.0	44.0	73.5	8.0
California	28,177	33,762,211	39,538,223	85.4%	83.5	7.7	28.1	40.5	7.7
Colorado	3,727	4,589,604	5,773,714	79.5%	81.2	12.3	35.6	41.1	13.3
Connecticut	2,370	2,779,755	3,605,944	77.1%	85.3	8.0	25.6	21.7	7.1
Delaware	1,308	989,948	989,948	100.0%	132.1	10.6	29.0	36.1	6.1
Hawaii	1,484	1,455,271	1,455,271	100.0%	102.0	9.2	33.8	45.5	11.2
Michigan	9,634	8,747,002	10,077,331	86.8%	110.1	7.7	28.8	37.6	11.6
Minnesota	3,246	4,651,998	5,706,494	81.5%	69.8	11.0	33.7	37.4	10.8
Mississippi	2,283	2,351,069	2,961,279	79.4%	97.1	6.0	15.4	39.6	9.2
Montana	645	884,017	1,084,225	81.5%	73.0	13.2	35.8	46.4	9.3
Nebraska	789	1,079,739	1,961,504	55.0%	73.1	15.7	40.5	48.4	10.2
North Carolina	8,749	8,817,221	10,439,388	84.5%	99.2	10.6	25.8	41.0	9.7
Oregon	3,050	3,801,921	4,237,256	89.7%	80.2	12.5	31.7	55.2	9.3
Pennsylvania	8,062	8,929,327	13,002,700	68.7%	90.3	8.8	28.1	35.8	14.5
Utah	1,539	3,271,616	3,271,616	100.0%	47.0	9.4	32.9	41.0	11.2
Vermont	498	643,077	643,077	100.0%	77.4	9.2	23.2	47.8	7.7
Washington	5,242	7,451,459	7,705,281	96.7%	70.3	12.7	36.8	52.9	10.2
Wisconsin	3,429	3,449,699	5,893,718	58.5%	99.4	9.8	28.7	35.1	9.5
District of Columbia	944	689,545	689,545	100%	136.9	6.5	20.0	29.2	6.0

Table 4. Public Reporting of State Aggregate Metrics, 2021.

CARES sincerely appreciates the willingness of state participants to voluntarily share this information. Reporting of state-level variation in bystander intervention rates and patient outcomes validates the importance of data collection for OHCA, promotes the sharing of best practices and helps facilitate system improvements to save lives nationwide.

Disparities in OHCA Outcomes

Incidence and outcomes of out-of-hospital cardiac arrest (OHCA) are affected by a variety of factors at the individual, community, and county levels. Some of these factors, such as those related to health care delivery and system performance, can be modified to improve patient outcomes, while others, such as patient sociodemographic characteristics, arrest location, and etiology, can be used to identify high-risk populations and disparities in care. Several studies have leveraged CARES data to highlight such disparities and identify individual- and community-level characteristics associated with patient survival outcomes. The findings from these studies can in turn be used to inform recommendations to improve patient outcomes in high-risk populations and communities.

One study, conducted by Saket et al.[11], found that the relative odds of survival to discharge varied by approximately 40% between counties (range: 3.4-22.0%), and the relative odds of survival with functional recovery varied by 53% (range: 0.8-20.1%). Underlying this county-level variation was a combination of cardiac arrest characteristics, bystander response, and sociodemographic characteristics. When evaluating quartiles by survival rate, there were significant differences with regard to the racial composition of county residents. Nearly 21% of residents in counties with the lowest survival were black in comparison with 6.2% of residents in the highest survival quartile. These findings highlight the large variation in survival ou tcomes for OHCA, as are illustrated with 2021 CARES data (page 40), and suggest that public health interventions, such as those that improve rates of bystander CPR, have the potential to improve survival, especially in low-performing counties that were found to have a disproportionately higher percentage of black residents.

Other studies have used CARES data to highlight outcome disparities at the more granular community level, looking at variation across neighborhoods and census tracts within counties. In one study, Sasson et al.[12] found that the incidence of OHCA and rates of bystander CPR can vary significantly among different neighborhoods within a single county. In Fulton County, Georgia, people that experienced cardiac arrest in a census tract in the highest income quintile were roughly five times more likely to receive bystander CPR compared to those in the lowest income quintile. Moreover, census tracts with a higher incidence of cardiac arrest and lower rates of bystander CPR, categorized as 'higher-gain' neighborhoods, had more Black residents (range: 43.2 - 98.2%; Fulton County mean: 44.6%), lower median household income (range: $13,880 - $45,525; Fulton County median: $47,321), and fewer high school graduates (46.7 - 86.1%; Fulton County mean: 84.0%).[13]

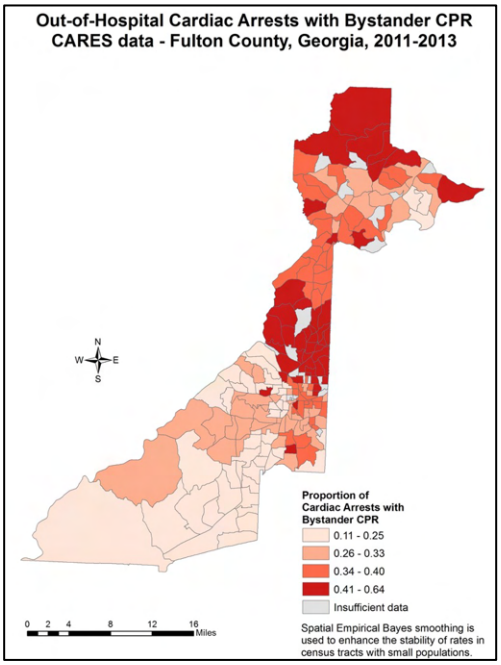


Figure 1. Distribution of adjusted bystander CPR prevalence by census tract in Fulton County, Atlanta, GA, 2011-2013.

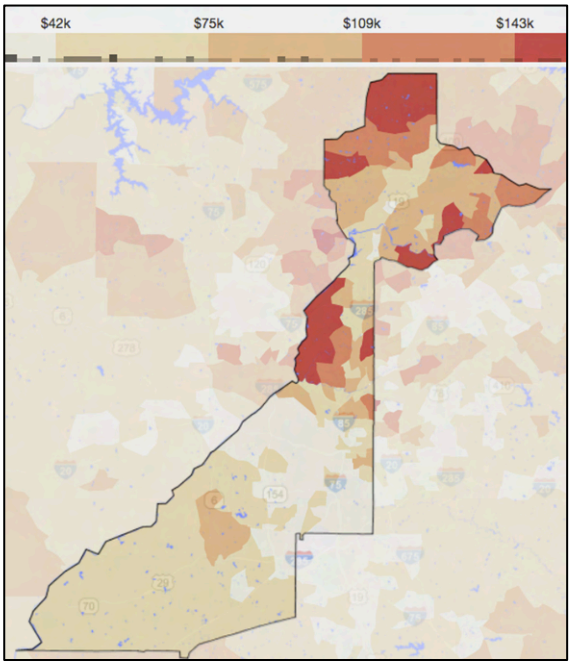


Figure 2. Distribution of median household income by census tract in Fulton County, Atlanta, GA, 2011-2013.

[11] Girotra S, van Diepen S, Nallamothu BK, Carrel M, Vellano K, Anderson ML, McNally N, Abella B, Sasson C, Chan PS; in collaboration with CARES Surveillance Group and the HeartRescue Project. Regional Variation in Out-of-Hospital Cardiac Arrest Survival in the United States. Circulation. 133(22):2159-68.

[12] Sasson C, Keirns CC, Smith DM, Sayre MR, Macy ML, Meurer WJ, McNally BF, Kellermann AL, Iwashyna TJ. Examining the contextual effects of neighborhood on out-of-hospital cardiac arrest and the provision of bystander cardiopulmonary resuscitation. *Resuscitation*. 82(6):674-9.

[13] Sasson C, Keirns CC, Smith D, Sayre M, Macy M, Meurer W, McNally BF, Kellermann AL, Iwashyna TJ, CARES Study Group. Small area variations in out-of-hospital cardiac arrest: does the neighborhood matter? *Ann Intern Med*. 153(1):19-22 (2010).

In a subsequent analysis, Sasson et al.[14] found a direct relationship between the median income and racial composition of a neighborhood and the probability that a person with out-of-hospital cardiac arrest received bystander-initiated CPR. This association was most apparent in low-income black neighborhoods, where the odds of receiving bystander-initiated CPR were approximately 50% lower than in high-income non-black neighborhoods (Figure 3).

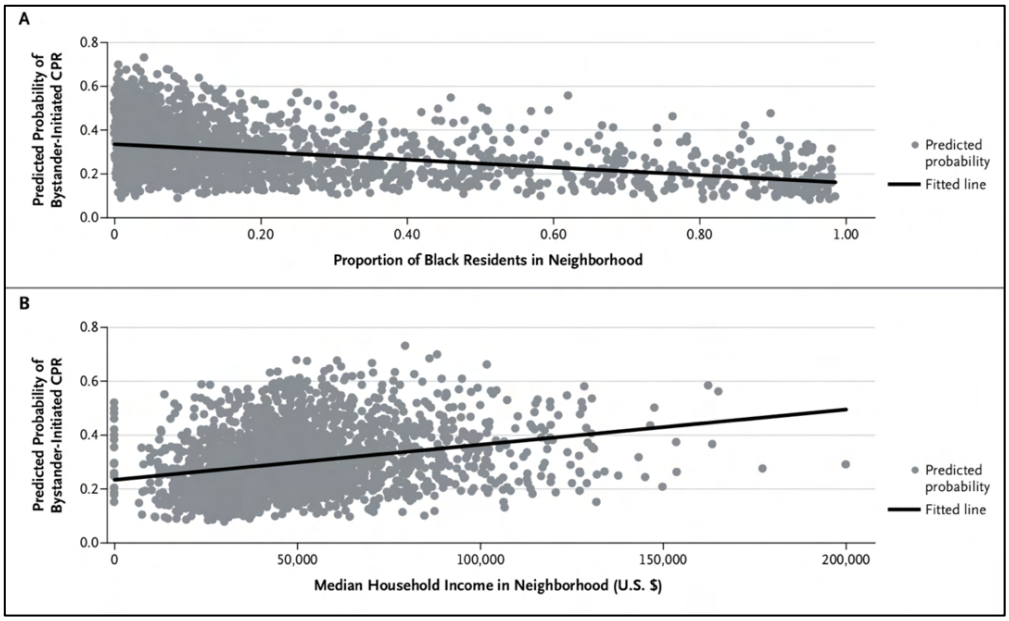


Figure 3. Unadjusted rates of survival outcomes by categories of neighborhood race and income.

Figure from Sasson C et al. Association of neighborhood characteristics with bystander-initiated CPR. N Engl J Med. 367(17):1607-15. Reprinted with permission.

Building on this research, Chan et al.[15] leveraged CARES data to examine the differences in rates of survival to discharge and favorable neurological outcomes among adults by neighborhood race and income. The analysis revealed similar trends to those described by Sasson et al. - patients with an out-of-hospital cardiac arrest in majority Black neighborhoods were 12% less likely to survive to discharge and 24% less likely to survive without severe neurological disability than those in predominantly White neighborhoods. In addition, rates of survival to discharge and favorable neurological survival were both lower in low- and middle-income neighborhoods as compared with high-income neighborhoods (Figure 4).

Disparities in bystander CPR provision were also observed in the pediatric sub-population. Naim et. al[16] studied the association between pediatric cardiac arrest victims' age, race/ethnicity, and neighborhood racial and socioeconomic factors with outcomes. Bystander CPR was 27% more common in high-income neighborhoods (median household income >$50,000) compared with low-income neighborhoods (median household income <$50,000), 33% more common in low-unemployment neighborhoods (unemployment <10%) compared with high-unemployment neighborhoods (unemployment <10%), and 50% more common in high-education (high school degree >80%) compared with low-education neighborhoods (high school degree <80%).

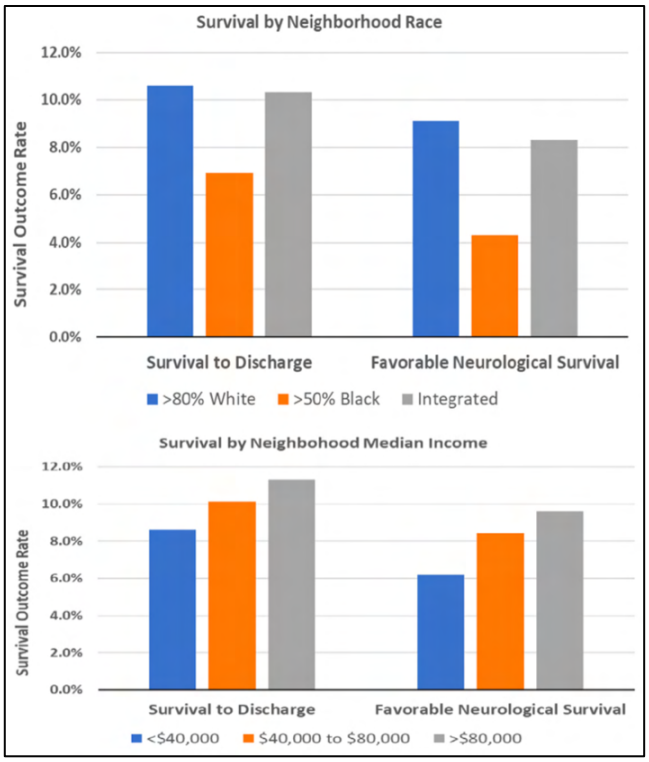


Figure 4. Unadjusted rates of survival outcomes by categories of neighborhood race and income.

Figure from Chan et al. Association of Neighborhood Race and Income With Survival After Out of Hospital Cardiac Arrest. J Am Heart Assoc. 9:e014178.

[14] Sasson C, Magid DJ, Chan P, Root ED, McNally BF, Kellermann AL, Haukoos JS. Association of neighborhood characteristics with bystander-initiated CPR. *N Engl J Med*. 367(17):1607-15.

[15] Chan P, McNally B, Vellano K, Tang Y, Spertus JA. Association of Neighborhood Race and Income With Survival After Out of Hospital Cardiac Arrest. J Am Heart Assoc. 9:e014178.

[16] Naim MY, Burke RV, McNally BF, Song L, Griffis HM, Berg RA, Vellano K, Markenson D, Bradley RN, Rossano JW. Association of Bystander Cardiopulmonary Resuscitation With Overall and Neurologically Favorable Survival After Pediatric Out-of-Hospital Cardiac Arrest in the United States: A Report From the Cardiac Arrest Registry to Enhance Survival Surveillance Registry. *JAMA Pediatr*. 171(2):133-141.

Findings from published CARES studies suggest that resuscitation care may differ at the individual- and community- level, with racial and socioeconomic factors influencing the likelihood that an individual receives bystander intervention (CPR or AED application) or survives an out-of-hospital cardiac arrest. Recognizing these disparities, high-risk areas can be identified, and community-based educational programs implemented. Quality improvement efforts aim to strengthen the links in the "chain of survival": activation of the emergency response system, immediate and high-quality CPR, rapid defibrillation, advanced EMS resuscitation, and post-arrest care. Community-based interventions such as bystander CPR and public access defibrillation, if initiated before 911 responders arrive, can significantly improve OHCA survival.

Chicago, the third largest and one of the most racially and socioeconomically diverse cities in the US, is one such success story, where the implementation of evidence-based interventions since 2011 has substantively improved OHCA outcomes. The city, previously known for low OHCA survival, has extensively reformed its approach to the treatment of OHCA by using data to guide improvements throughout the system of care, including (1) training EMS call takers and dispatchers from the Chicago Fire Department to improve recognition of OHCA and provide telephone-assisted CPR instructions to callers, (2) simulation-based training sessions defining high-performance CPR quality metrics and emphasizing high quality chest compressions with early defibrillation, and (3) joining CARES in order to systematically collect OHCA data and benchmark.[17] Figure 5 below shows the implementation timeline of various interventions in the Chicago area alongside increased survival rates for all rhythms for the years 2013-2016.

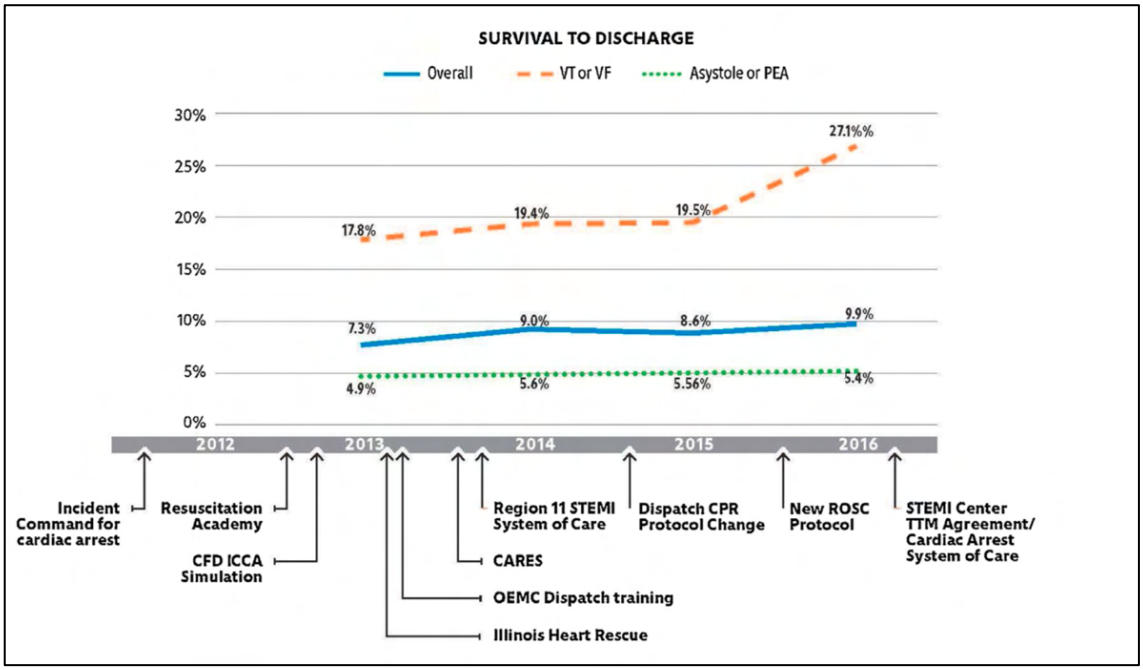


Figure 5. Observed rates for survival to discharge for the overall cohort and by shockable and nonshockable presenting rhythms. Increased survival rates were observed for all rhythms in close temporal association with the implementation of multiple pre-hospital interventions.

Figure from Del Rios M et al. Large urban center improves out-of-hospital cardiac arrest survival. Resuscitation. 139:234-240. Reprinted with permission.

Denver is another city that has utilized CARES data to tailor interventions to better meet the needs of high-risk populations. Its HANDDS (identifying High Arrest Neighborhoods to Decrease Disparities in Survival) program is changing the paradigm of community bystander CPR training, shifting away from a one-size-fits-all approach to one that is responsive to community-specific needs and resources.[18] The program uses a simple three-step approach: 1) identify high-risk neighborhoods, 2) understand common barriers to learning and performing CPR in these neighborhoods, and 3) implement and evaluate a train-the-trainer CPR Anytime intervention designed to improve CPR training in these communities. In the pilot trial, the community-based CPR educational program was tailored to the needs of specific racial, ethnic, and socioeconomic groups (e.g., Spanish-language training); was conducted in local settings based on community preferences (at churches and schools); and leveraged local resources (e.g. recruiting local bilingual residents as health educators). However, the results of this intervention have not yet been reported.

[17] Del Rios M, Weber J, Pugach O, Nguyen H, Campbell T, Islam S, Stein Spencer L, Markul E, Bunney EB, Vanden Hoek T. Large urban center improves out-of-hospital cardiac arrest survival. *Resuscitation*. 139:234-240.

[18] Sasson, C, Haukoos, JS, Eigel, B, & Magid, DJ. The HANDDS program: a systematic approach for addressing disparities in the provision of bystander cardiopulmonary resuscitation. *Academic Emergency Medicine*. 21(9), 1042–1049.

Another example of how CARES data has highlighted opportunities to improve survival outcomes in high-risk communities involves the potential use of drones to quickly deliver an AED to bystanders at the scene of a witnessed OHCA. While timely use of an AED is known to dramatically improve the chances of survival, the demographic makeup and other essential features of a community predict OHCA treatment variability and may influence whether bystanders can and will rapidly and successfully apply an AED for defibrillation. A pilot program currently underway in North Carolina aims to explore the association of community phenotypic clusters on current OHCA treatment patterns in high OHCA-incidence communities and assess the need of an emergency drone network within the community.[19]

The studies and interventions featured above demonstrate the value of surveillance and monitoring data in identifying high-risk populations and unmet needs, tailoring interventions to meet those needs, and evaluating the effectiveness of initiatives to improve OHCA response at the community level. Systematic implementation of evidence-based, quality improvement initiatives coupled with focused community engagement and surveillance can improve survival outcomes in systems with historically low OHCA survival rates. Using 2021 CARES data, the table below shows key OHCA interventions and outcomes by patient race/ethnicity and gender, as well as by neighborhood racial composition and median household income. CARES data both reflects the trends highlighted in the above-mentioned studies and identifies additional high-risk populations for future studies and interventions. CARES data shows a strong correlation between the racial composition of the neighborhood in which an OHCA occurs and patient outcomes - majority White (≥ 70%) neighborhoods had the highest survival rate (9.7%), neighborhoods with large Black populations (≥ 40%) had the lowest survival rate (7.5%), and integrated neighborhoods had intermediate patient outcomes (9.0%). Similarly, bystander CPR provision and public AED use were consistently associated with both neighborhood racial composition and median household income. These data highlight the importance of investing in underserved communities to promote better patient outcomes and an increase in the use of key interventions such as bystander CPR and AED use.

	Overall Survival to Hospital Discharge (%)	CPR (%)	Public AED Use (%)
Total	**13,402/146,924 (9.1%)**	**44,673/11,1171 (40.2%)**	**1,742/17,134 (10.2%)**
Race/Ethnicity			
American-Indian/Alaska	38/525 (7.2%)	167/426 (39.2%)	8/91 (8.8%)
Asian	328/3,645 (9.0%)	1,236/2,893 (42.7%)	33/389 (8.5%)
Black/African-American	2,562/31,938 (8.0%)	7,719/23,059 (33.5%)	292/3,345 (8.7%)
Hispanic/Latino	1,061/12,593 (8.4%)	3,824/9,950 (38.4%)	125/1,642 (7.6%)
Native Hawaiian/Pacific Islander	76/802 (9.5%)	311/650 (47.8%)	5/88 (5.7%)
White	7,261/73,319 (9.9%)	23,395/55,435 (42.2%)	989/8,512 (11.6%)
Unknown	2,026/23,602 (8.6%)	7,879/18,387 (42.9%)	284/3,005 (9.5%)
Multi-Racial	50/500 (10%)	142/371 (38.3%)	6/62 (9.7%)
Gender			
Male	8,661/91,864 (9.4%)	28,868/71,459 (40.4%)	1,413/13,364 (10.6%)
Female	4,736/55,012 (8.6%)	15,795/39,679 (39.8%)	329/3,766 (8.7%)
Neighborhood Racial Composition			
≥70% White	7,161/74,042 (9.7%)	24,212/56,529 (42.8%)	930/8,530 (10.9)
≥40% Black	1,710/22,806 (7.5%)	5,498/17,114 (32.1%)	163/2,314 (7.0%)
Integrated	4,485/49,902 (9.0%)	14,880/37,384 (39.8%)	596/6,170 (9.7%)
Neighborhood Median Household Income			
<$40,000 Annually	4,070/44,711 (9.1%)	12,411/33,792 (36.7%)	442/5,418 (8.2%)
$40,000-$80,000 Annually	6,111/68,619 (8.9%)	20,877/51,820 (40.3%)	732/7,544 (9.7%)
>$80,000 Annually	3,138/33,001 (9.5%)	11,123/25,092 (44.3%)	442/3,885 (11.4%)

Table. Differences in Bystander Interventions and Survival After OHCA, by Race/Ethnicity, Gender, and Neighborhood Characteristics, CARES 2021.

[19] Starks MA, Sperling J, Cardenas A, Blewer AL, Sharpe E, Buckland DM, Joiner A, Zegre-Hemsey J, Mark DB. Barriers and Opportunities for a Drone-Delivered AED Network in Durham, North Carolina. American Heart Association Resuscitation Symposium, 2020 November 14-15; Virtual.

2021 Publications

A comprehensive list of CARES publications to-date can be viewed at: https://mycares.net/sitepages/publications.jsp.

Peer-Reviewed Publications

- Berry CL, Olaf MF, Kupas DF, Berger A, Knorr AC, the CARES Surveillance Group. **EMS Agencies with High Rates of Field Termination of Resuscitation and Longer Scene Times Also Have High Rates of Survival**. *Resuscitation*. 169:205-213.
- Coute RA, Nathanson BH, Kurz MC, DeMasi S, McNally B, Mader TJ. **Annual and lifetime economic productivity loss due to adult out-of-hospital cardiac arrest in the United States: A study for the CARES Surveillance Group**. *Resuscitation*. 167:111-117.
- Coute RA, Nathanson BH, Mader TJ, McNally B, Kurz MC. **Trend analysis of disability-adjusted life years following adult out-of-hospital cardiac arrest in the United States: A study from the CARES Surveillance Group**. *Resuscitation*. 163:124-129.
- Naim MY, Griffis HM, Berg RA, Bradley RN, Burke RV, Markenson D, McNally BF, Nadkarni VM, Song L, Vellano K, Vetter V, Rossano JW. **Compression-Only Versus Rescue-Breathing Cardiopulmonary Resuscitation After Pediatric Out-of-Hospital Cardiac Arrest**. *J Am Coll Cardiol*. 78(10):1042-1052.
- Kotini-Shah P, Del Rios M, Khosla S, Pugach O, Vellano K, McNally B, Vanden Hoek T, Chan PS. **Sex differences in outcomes for out-of-hospital cardiac arrest in the United States**. *Resuscitation*. 163:6-13.
- Morris NA, Mazzeffi M, McArdle P, May TL, Burke JF, Bradley SM, Agarwal S, Badjatia N, Perman SM, the CARES Surveillance Group. **Women receive less targeted temperature management than men following out-of-hospital cardiac arrest due to early care limitations**. *Resuscitation*. 169:97-104.
- Morris NA, Mazzeffi M, McArdle P, May TL, Waldrop G, Perman SM, Burke JF, Bradley SM, Agarwal S, Figueroa JF, Badjatia N, the CARES Surveillance Group. **Hispanic/Latino-Serving Hospitals Provide Less Targeted Temperature Management Following Out-of-Hospital Cardiac Arrest.** *J Am Heart Assoc.* 10(24):e017773.
- Shin J, Chocron R, Rea T, Kudenchuk P, McNally B, Eisenberg M. **Merits of expanding the Utstein case definition for out of hospital cardiac arrest**. *Resuscitation*. 158:88-93.
- Huebinger R, Jarvis J, Schulz K, Persse D, Chan HK, Miramontes D, Vithalani V, Troutman G, Greenberg R, Al-Araji R, Villa N, Panczyk M, Wang H, Bobrow B. **Community Variations in Out-of-Hospital Cardiac Arrest Care and Outcomes in Texas**. *Prehosp Emerg Care*. 26(2):204-211.
- Huebinger R, Vithalani V, Osborn L, Decker C, Jarvis J, Dickson R, Escott M, White L, Al-Araji R, Nikonowicz P, Villa N, Panczyk M, Wang H, Bobrow B. **Community disparities in out of hospital cardiac arrest care and outcomes in Texas**. *Resuscitation*. 163:101-107.
- Moeller S, Hansen CM, Kragholm K, Dupre ME, Sasson C, Pearson DA, Tyson C, Jollis JG, Monk L, Starks MA, McNally B, Thomas KL, Becker L, Torp-Pedersen C, Granger CB. **Race Differences in Interventions and Survival After Out-of-Hospital Cardiac Arrest in North Carolina, 2010 to 2014**. *J Am Heart Assoc*. 10(17):e019082.
- Hamam MS, Klausner HA, France J, Tang A, Swor RA, Paxton JH, O'Neil BJ, Brent C, Neuumar RW, Dunne RB, Reddi S, Miller JB. **Prehospital Tibial Intraosseous Drug Administration is Associated with Reduced Survival Following Out of Hospital Cardiac Arrest: A study for the CARES Surveillance Group**. *Resuscitation*. 167:261-266.
- Swor RA, Chen N, Song J, Paxton JH, Berger DA, Miller JB, Pribble J, Reynolds JC. **Hospital length of stay, do not resuscitate orders, and survival for post-cardiac arrest patients in Michigan: A study for the CARES Surveillance Group**. *Resuscitation*. 165:119-126.
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- Abir M, Fouche S, Lehrich J, Goldstick J, Kamdar N, O'Leary M, Nelson C, Mendel P, Nham W, Setodji C, Domeier R, Hsu A, Shields T, Salhi R, Neumar RW, Nallamothu BK, CARES Surveillance Group. **Variation in pre-hospital outcomes after out-of-hospital cardiac arrest in Michigan**. *Resuscitation*. 158:201-207.

Abbreviations & Definitions

AED	Automated External Defibrillator
CARES	Cardiac Arrest Registry to Enhance Survival
CPC	Cerebral Performance Category
CPR	Cardiopulmonary Resuscitation
DNR	Do Not Resuscitate
ED	Emergency Department
EMS	Emergency Medical Services
OHCA	Out-Of-Hospital Cardiac Arrest
PEA	Pulseless Electrical Activity
ROSC	Return of Spontaneous Circulation
SIDS/SUID	Sudden infant death syndrome/Sudden unexpected infant death
TOR	Termination of resuscitation
VF	Ventricular Fibrillation
VT	Ventricular Tachycardia

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