CARES 2022

Annual Report

CARES
Cardiac Arrest Registry to Enhance Survival

mycares.net

Cardiac Registry to Enhance Survival (CARES)

Annual Report 2022

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Introduction

Atascocita Fire Department (Texas) hosts an EMT skills certification event.

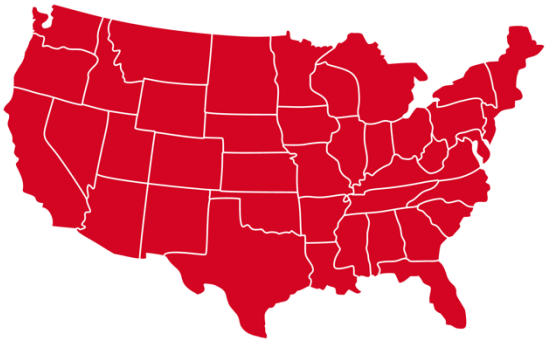
EMS-treated out-of-hospital cardiac arrest (OHCA) affects more than 250,000 Americans each year and is the third leading cause of disability adjusted life years (DALY) in the United States, behind cardiovascular disease and back pain. Typically, one in ten patients survives to hospital discharge, with 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.

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 are able to 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 2022, more than 11,000 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 2022 Annual Report.



147,736

NON-TRAUMATIC, WORKED OHCAS WERE REPORTED TO CARES IN 2022.

CARES covers a catchment area of more than 175 million, including 30 statewide registries and 60 community sites. More than 2,300 EMS agencies and over 2,500 hospitals participate nationwide.

40.0%

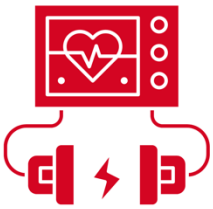
OF PATIENTS RECEIVED BYSTANDER CPR

Median EMS response time: **7.8 minutes**.

26.7% of patients achieved sustained Return of Spontaneous Circulation (ROSC) in the field.

11.3%

OF PATIENTS WHO ARRESTED IN PUBLIC HAD A BYSTANDER APPLIED AED

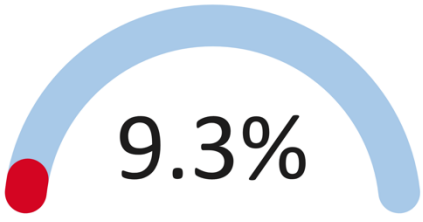


24.9%

OF PATIENTS SURVIVED TO HOSPITAL ADMISSION

41.4%

OF ADMITTED PATIENTS RECEIVED HYPOTHERMIA CARE



OF PATIENTS SURVIVED TO HOSPITAL DISCHARGE

OF DISCHARGED PATIENTS HAD A POSITIVE NEUROLOGICAL OUTCOME (CPC 1 OR 2)

A Year in Review

Dear CARES Community,

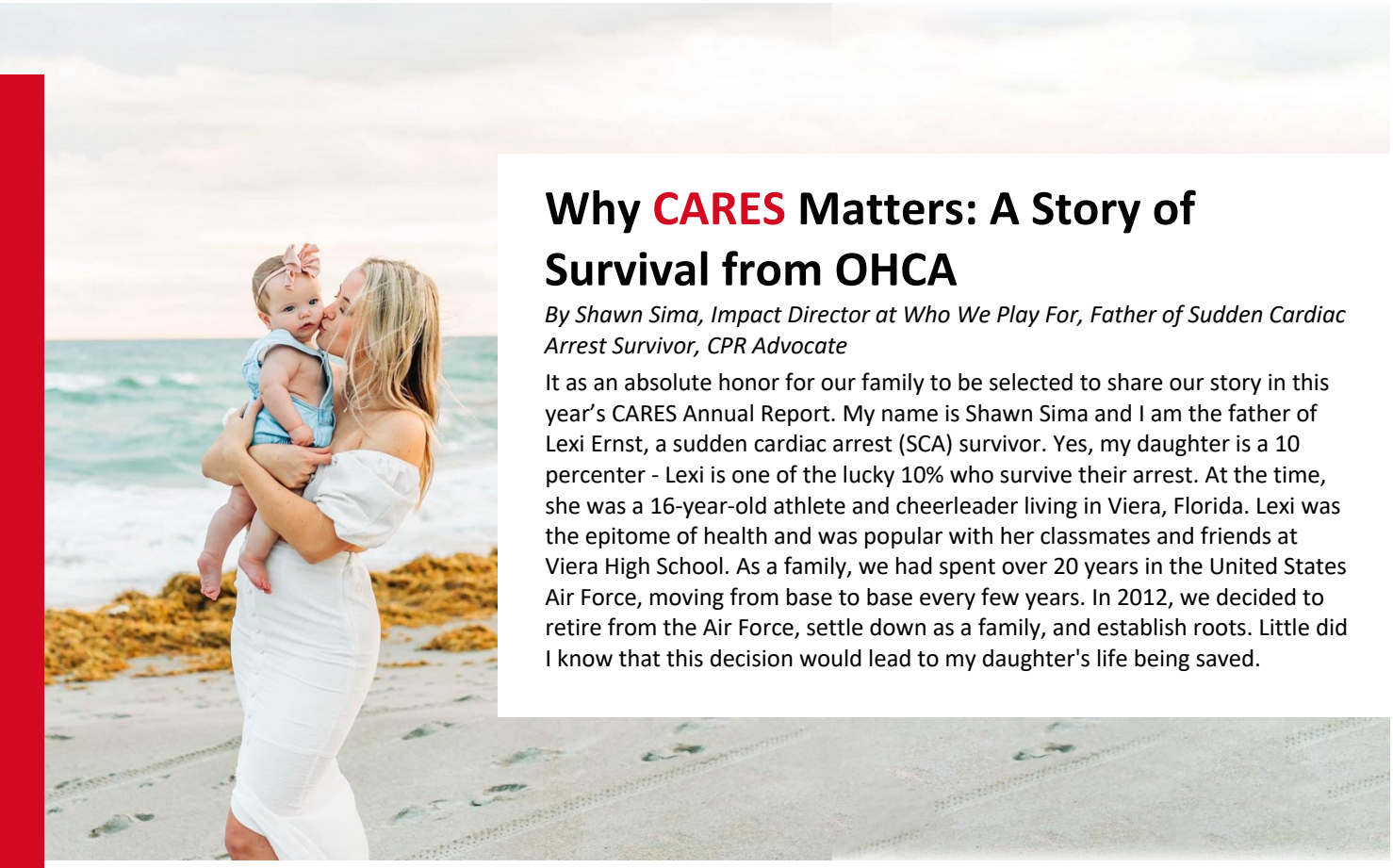
If 2022 was the year of resilience, 2023 looks to be the year of advancement in resuscitation practice. The millionth patient was entered in CARES earlier this year which deserves a moment of pause. The 2022 CARES National reports published last week acknowledge positive signs of recovery in overall cardiac arrest survival, bystander defibrillation in public locations, and continuity in community-based CPR efforts, reversing downward trends since the onset of the pandemic. Many Americans added cardiac arrest to their vocabulary after witnessing the collapse, resuscitation, and eventual recovery of Damar Hamlin during a widely televised NFL playoff game. This national moment precipitated a surge in online interest to learn bystander CPR and more recently has led to a collective commitment of all major sports leagues to promote CPR training and development of emergency response plans in schools countrywide.

New funding that will advance CARES expansion to all 50 states over the next five years while providing for dedicated improvement activities nationally became a reality on two fronts. The first is a result of Congressional passage of the CAROL Act late last year that will appropriate 25 million dollars in funding over five years (2023-2027), as part of a public-private partnership (American Red Cross, American Heart Association, CDC, HHS, and Emory University). Goals include expansion of CARES while strengthening the existing partnership with the Seattle based Resuscitation Academy team and promoting the NHTSA CPR LifeLinks curriculum (dispatcher assisted CPR and professional team-based CPR training) with colleagues at the University of Texas-Houston. A more coordinated approach to measurement and improvement activities will be realized through a regional implementation plan nationally. A sincere note of thanks to the American Heart Association and American Red Cross Government Affairs teams and all the local and state level efforts advocating for this federal legislation which would not have been possible without this coordinated effort. The second funding announcement will be made public later this month.

We are proud to present the 2022 CARES Annual Report that highlights survivors, CARES in Action stories, and impactful research publications. The survivor wall is a testament to your efforts and a reminder about the work that remains ahead. Two publications that deserve greater attention include CARES Trend Data from 2015-2019, that found improvement in both overall and witnessed cardiac arrest survival. The second article received significant visibility in the NEJM and found that Black and Hispanic patients with witnessed cardiac arrest in public settings were even less likely to receive bystander CPR than in a residential setting. This disparity existed irrespective of neighborhood demographics, suggesting implicit or explicit bias.

We hope you enjoy the 2022 CARES Annual Report and look forward to sharing more information soon about CARES expansion efforts nationally.

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



Why CARES Matters: A Story of Survival from OHCA

By Shawn Sima, Impact Director at Who We Play For, Father of Sudden Cardiac Arrest Survivor, CPR Advocate

It as an absolute honor for our family to be selected to share our story in this year's CARES Annual Report. My name is Shawn Sima and I am the father of Lexi Ernst, a sudden cardiac arrest (SCA) survivor. Yes, my daughter is a 10 percenter - Lexi is one of the lucky 10% who survive their arrest. At the time, she was a 16-year-old athlete and cheerleader living in Viera, Florida. Lexi was the epitome of health and was popular with her classmates and friends at Viera High School. As a family, we had spent over 20 years in the United States Air Force, moving from base to base every few years. In 2012, we decided to retire from the Air Force, settle down as a family, and establish roots. Little did I know that this decision would lead to my daughter's life being saved.

On the night of February 2, 2016, Lexi left her high school softball game and decided to go for a run at the local gym before her cheerleading tryouts the next day. At 7:57pm, I got the worst text a parent can ever receive from a friend -- "GET HERE NOW, THIS SEEMS BAD". Within seconds of starting her run, Lexi had gone into cardiac arrest and collapsed. Thankfully, several bystanders were in the gym that night, including Jack Rhodes, a retired Air Force Senior Non-Commissioned Officer, who had recently taken a CPR/AED course. Fellow bystanders Bill Sick, John Lynch, and Amanda Miller offered their help and the group performed CPR and shocked Lexi with an automated external defibrillator (AED), bringing her back to life. There is no doubt in my mind that Lexi would not have survived that night without bystander CPR and defibrillation, as EMS arrived on scene more than 12 minutes later.

As we waited through the following 72 hours while Lexi was in a medically induced coma, I did my research. As a healthcare provider who has performed thousands of pediatric physicals, my knowledge of SCA was admittedly limited. I had no clue how prolific a killer cardiac arrest was. For three days, we wondered if our girl would wake up and if she did, what her life would look like. Needless to say, I prayed often that she would be saved and returned to us whole. We felt completely helpless. Thankfully, after three days, Lexi woke up. She received an implanted cardiac defibrillator (ICD) during her hospital stay and was eventually released home. We immediately knew that our family wanted to pay it forward, as we wanted to make sure that no other parent would have to go through losing their child. We researched avenues for contribution, found that Florida was lacking in SCA awareness compared to other states, and decided to take action.

Paying It Forward

In July, I sent my first letter to the Brevard County Florida School Board, not realizing that one letter would open the door to making changes in our state and the country. In recent years, we have achieved significant progress in promoting and improving emergency response measures in our town and across Florida. This began in November 2017, when the Brevard County School District passed a policy requiring CPR and AED training as a graduation requirement. This was followed by the passage of Florida Law HB 7055 in early 2018, which encouraged CPR training for all students beginning in 6th grade and every two years thereafter. Later that year, we also played a key role in passing U.S. House Resolution 35, a national resolution that encourages public schools with AEDs to train personnel on their use during the time allocated for emergency first aid and CPR training.

In 2019, our organization, ***Who We Play For***, went even further by working to make ECG heart screenings a mandatory component of school sports physical examinations. Brevard and Osceola were the first counties in the United States to implement the requirement, which has now expanded to nine counties in Florida and has helped identify more than 250 kids with potentially deadly heart conditions.

In 2020, we helped pass the SCA-related portion of Florida Law HB 7011, also known as "The Zac Martin Act". The bill requires each public school that is a member of the Florida High School Athletic Association (FHSAA) to make its AED available on school grounds in a clearly marked, publicized location for each athletic contest, practice, workout, or conditioning session, including those outside of the school year. The bill also requires a school employee or volunteer with current training in CPR and AED use to be present at each athletic event on campus, and be made aware of each AED's location.

Lexi Sima revisits the scene of her arrest to thank her rescuers.

In 2021, we were successful in passing Florida Law HB 157, which requires public schools to provide CPR and AED training in 9th and 11th grades as a graduation requirement, empowering high school students and creating the next generation of lifesavers.

Together, these measures have greatly improved our community's ability to respond to emergencies and protect the lives of our youth. In 2017, Florida was ranked 23rd in the nation for state high school sports safety policy. I am thrilled to share that Florida has been ranked 1st in the nation for the past two years (2021 and 2022), making it the safest state for high school athletes.

Currently, a bipartisan national bill called the Access to AED Act is under consideration. If passed, this bill will direct the Secretary of Health and Human Services to award grants to public and private elementary and secondary schools partnered with nonprofit healthcare organizations to develop and implement comprehensive programs promoting access to AEDs in schools. These funds can be used to:

- Purchase AEDs and their necessary batteries and maintenance.
- Replace old and outdated CPR and AED equipment, machinery, and educational materials.
- Provide CPR and AED training to students, staff, and related sports volunteers.
- Develop a Cardiac Emergency Response Plan.
- Assist schools' athletic departments in developing heart screening programs for student athletes.
- Establish a clearinghouse database for the reporting of AED devices already in schools.
- Establish a clearinghouse database to gather information on sudden cardiac arrest in the pediatric population for further research.

Lexi and Shawn Sima visit the Florida Legislature to advocate for CPR training in schools.

I'm incredibly proud of the work that ***Who We Play For*** has accomplished to-date and look forward to continuing to advocate for policy changes to save lives. That being said, the greatest sources of joy in my life have unfolded because amazing individuals stepped forward to help save my daughter's life. We feel lucky with each passing milestone in Lexi's life - high school graduation, nursing school, marriage, and welcoming a beautiful baby girl, Kopelynn Grace, who holds a special place in our hearts. As we celebrate each milestone in Lexi's life, we recognize the significance of the Cardiac Arrest Registry to Enhance Survival (CARES) in collecting and analyzing data on pediatric sudden cardiac arrest, emphasizing the critical need for ongoing efforts to gather and utilize this information in communities nationwide.

Survivors of Cardiac Arrest

In 2022, CARES reported 13,794 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.

Pamela Maker

Charleston County EMS, SC

Immediate bystander CPR saved Pamela Maker's life after she suffered a sudden cardiac arrest in her home. Since her event, she has become a community spokesperson for the importance of CPR. She has become a CPR instructor and hosts community CPR events. She also started a nonprofit, "Let's Save a Life Foundation", to bring more awareness to sudden cardiac arrest.

Watch her story here…
Watch the reunion here…

Ken Iisaka

Texas Health Harris Fort Worth, TX

Classical music filled Bass Performance Hall as the pianist's fingers delicately danced across the keys. Hearing the applause and exiting the stage, Ken Iisaka collapsed, seconds after he finished performing. Thanks to Texas Health Harris Methodist Hospital Fort Worth using a new lifesaving protocol, a grateful Iisaka will soon be back at the keys.

Read more here…

Diana Swift

Taney County Ambulance, MO

While visiting from out-of-state, Diana Swift experienced a cardiac arrest. It's estimated that 15 -20 people were involved in delivering pre-hospital emergency care to Diana, including dispatchers from three dispatch agencies, first responders, and Taney County Ambulance's crew. Diana is most thankful to responders for giving her more time with her 5 grandchildren.

Read more here…

It Takes a Village

On the evening of August 11th, 2022, Falck Medic 107 and Aurora Fire Rescue Engine 10 (Colorado) were dispatched to a private residence for reports of a 1-year-old male that was pulseless and apneic. The patient's mother reported that he had become "unresponsive, turned blue and did not have a pulse". The units arrived on scene within 7 minutes and working in unison to provide life-saving measures. Due to the quick response of **City Dispatch**, the **Aurora Police Department**, **Falck**, and **Aurora Fire Rescue**, this child was able to leave the hospital neurologically intact. Today he is healthy, happy and with his family.

CARES
Cardiac Arrest Registry
to Enhance Survival

Literal Lifesavers

Meet the heroes of 2022. These six individuals were all aided in their cardiac arrest recovery by strangers.

Jerry Parris

Ann Arbor Fire Department, MI

Daniel Mendez called 911 while David Canada started CPR after Jerry collapsed at an ultimate frisbee game. Fortunately, David had taken part in a CPR training just weeks prior. After an intense 10 minutes of CPR, Jerry's color returned, and paramedics arrived.

Read more here…

Tom Colbert

Fairfax County Fire & Rescue, VA

Tom Colbert was playing golf when he collapsed. Six bystanders immediately stepped up to help. They started CPR and retrieved an AED from an outdoor access box on the course and provided defibrillation and CPR.

Watch the resuscitation reunion here…

Kamathi Long

Crowley Fire, TX

Athletic trainer Amanda Ortega was off duty attending her son's basketball game in Crowley, TX. Half-way through the game, a 17-year-old player from the opposing team went into cardiac arrest. Amanda sprinted down from the stands, began CPR, and used the AED that the team had brought to courtside.

Read more here…

Josiah Yeadon

Dorchester County EMS, SC

When 13-year-old Josiah left the locker room after football practice, he collapsed on the field. As soon as athletic trainer Amanda Moon caught wind of what happened from other students, she sprang into action and used an AED defibrillator on the teen.

Read more here…

Mike Garland

Delhi Township Fire Department, MI

Two weeks into retirement, former Michigan State University basketball coach, Mike Garland was driving with his wife when he suffered a cardiac arrest and struck a tree. Within seconds, two men stopped and took action. Mike started a non-profit, "Champions of the Heart", to raise awareness in his community.

Read more here…

Larry Friel

GMR Waterbury, CT

Larry was dining with a group of 40 people when his heart suddenly stopped. Jill Irwin, a dental hygienist that learned CPR several years prior, put her skills training to use for the first time ever.

Read more here…

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 Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, Washington and Wisconsin) plus 50 community sites in 16 additional states, representing a catchment area of approximately 175 million people or 53% of the US population. To date, the registry has captured over 1 million records, with more than 2,300 EMS agencies and over 2,500 hospitals participating nationwide.

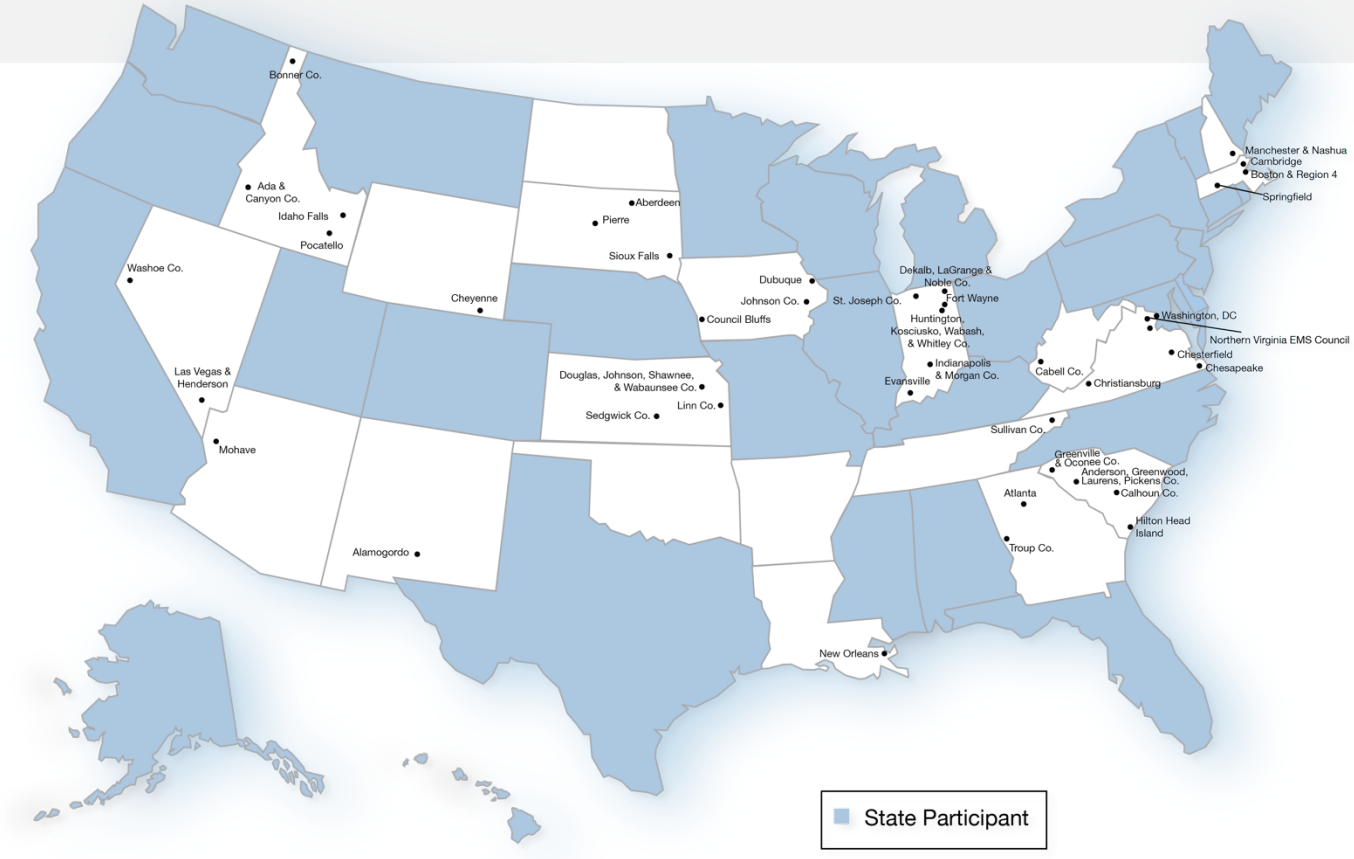


Figure 1. Map of 2022 CARES Participants

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[1,2]. 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, including coronary angiography, CABG, and stent or ICD placement.

CARES required data fields are harmonized with NHTSA's National EMS Information System (NEMSIS) version 3.5. Future efforts will focus on alignment of CARES supplemental data fields with NEMSIS v3.6.

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.

[1] 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.

[2] 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.

In 2022, more than 11,000 reports were generated during the three-day reporting period.

CARES in Action

Resuscitation Academy Lighthouses: Beacons of Light

By Tegan Hampton, MHA, Resuscitation Academy Network Manager

The Resuscitation Academy Foundation (RAF) was founded in 2008 to transfer Seattle/King County's lessons on optimizing an EMS system's chain of survival. Twice per year, EMS leaders from around the world gather in Seattle to learn and exchange ideas on how to save more lives. Our ultimate mission is to create a world where no one dies from cardiac arrest.

To help achieve this mission, the RAF created the Lighthouse program. Today, there are 10 lighthouses across the United States with this designation. They are communities who volunteer to take this mission on with us because of their passion for saving lives. Lighthouses help expand the organization's reach and amplify its work. Organizations must embody the 10 Steps to achieve Lighthouse designation. Criteria include providing low-dose, high-frequency high-performance CPR and telephone CPR training; providing regular and non-punitive feedback to responders; entering data into a registry; and committing to constant improvement. In addition – and crucially – they must commit to helping other communities improve, and to be true beacons of leadership in their regions.

Two of our Lighthouses – Maryland and Kentucky – share their stories about local measurement and QI efforts below. We are honored to work with both of them, as well as with all of our RA Lighthouses, and we are grateful for their support.

Jessamine County: It Takes a System to Save a Victim

By Jamie Goodpaster, Chief of EMS, Jessamine County EMS, Kentucky

Jessamine County EMS started its journey to improve survival in March of 2018. The Kentucky Board of EMS selected four individuals to attend the Resuscitation Academy Leadership Program in Seattle, Washington. One of the individuals selected was Jessamine County EMS Chief, Jamie Goodpaster. The RA program provided remarkable insight into how to improve cardiac arrest survival. To this day, it remains our manual for success. Despite leadership buy-in and a roadmap for navigating the elements of improved survival, we needed a program coordinator that would spearhead the initiatives outlined by the Resuscitation Academy. In December 2018, Floyd Miracle was hired as Clinical Manager and was given the primary directive to improve cardiac arrest survival within Jessamine County. He hit the ground running -- within four months he had attended the Resuscitation Academy Leadership Program, and within six months we had enrolled in CARES and were submitting data.

We quickly tackled many of the steps to improve cardiac arrest survival. Notably, we started with the step that we felt would provide the highest yield: establish a cardiac arrest registry. In lieu of creating our own registry, we felt that it was imperative to meet the highest quality standard and to have a reliable, evidence-based infrastructure to streamline our data collection processes and isolate specific quality improvement objectives. It was evident from the outset that we could not accomplish our goals without bringing major community stakeholders together.

We wanted to ensure that we had the highest quality data for our CARES registry. This meant that we needed our independent PSAP center, Jessamine County E911, to buy in to not only CARES, but also telecommunicator CPR and rapid dispatch. They quickly became partners with our agency and made our mission their own. We began using the DA-CPR section of CARES as a framework for the data we needed to obtain from our PSAP and developed internal processes for obtaining the audio recordings and CAD data, which in turn catalyzed a change in T-CPR protocols, standardized T-CPR training for all dispatchers, and a process for reviewing the data and identifying areas for improvement.

Paramedics from Jessamine County EMS hone their life-saving skills through a CPR training exercise.

Over the last four years we have celebrated remarkable success within our system. Our partnership with Jessamine County E911 has truly made a difference in our community and the standards within our department. Critical to these improvements has been the implementation of CARES. We now have critical and timely reports that isolate our performance and our impact on the community. The transparency of data that CARES provides allows us to communicate with our stakeholders, provide timely and necessary quality improvement, give critical feedback, and most of all celebrate our survival in a meaningful and positive way. Armed with this data, we have seen our Utstein Survival increase from 12.5% (CY2019) to 25% (CY2022). In addition, because we submit dispatch data along with our EMS data, we have seen our Bystander CPR with dispatcher assistance increase from 9.4% (CY2019) to 36.6% (CY2022). These marked improvements could not be accomplished without CARES.

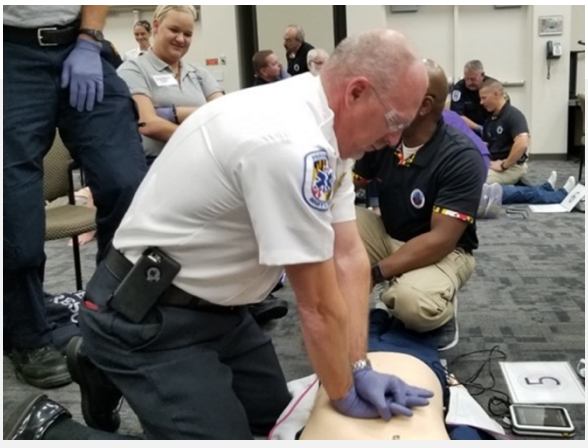
	CY2019	CY2022
Utstein Survival	12.5%	25%
Bystander CPR with dispatcher assistance	9.4%	36.6%

Jessamine County EMS continues to mobilize stakeholders and utilize CARES data to improve our overall impact on the community. Through reliable, accurate, and whole data with thoughtful leadership and deliberate execution, enhanced survival in Jessamine County is inevitable.

Maryland: Working Toward a World Where No One Dies of Cardiac Arrest

By Kevin Seaman, MD, FAEMS, FACEP, Medical Director, Maryland Resuscitation Academy

Home to more than 6 million people, Maryland is located in the mid-Atlantic region, stretching from the Atlantic Ocean to the Appalachian Mountains, covering more than 12,000 square miles just north of Washington, D.C. and northern Virginia, and south of Pennsylvania. Central Maryland is generally urban, while the remainder of the state is more rural.



Since the early 1970s, Maryland has a statewide system of EMS and cardiovascular care, coordinated by the Maryland Institute for EMS Systems (MIEMSS). The state is divided into five regions, with hospitals (both general use and specialty cardiovascular and cardiac arrest receiving centers) distributed throughout the regions to allow systemwide distribution of the most critically ill cardiac arrest patients.

Foundation

Maryland takes a systems-based approach to EMS across the entire state. When Dr. R. Adams Cowley established the state EMS system in the 1970s he stated: "According to JAMA, Standards for CPR and ECC ... About 350,000 of these deaths occur outside the hospital usually within two hours of the onset of symptoms. Thus sudden death ... remains the gravest medical emergency today." Those words are as true today as when they were first spoken, almost 50 years ago.

From its inception, Maryland has initiated and grown a statewide EMS system, with a single EMS protocol and a single EMS patient care report. We have a statewide network of Cardiac Intervention Centers to which cardiac arrests are transported and the latest patient care report, eMEDS (an Image Trend product), is used in every one of the 24 counties and two cities across the state, completed in 2016. This formed the foundation for the rollout of CARES across the state in 2017. MIEMSS shares our performance and publishes Maryland's CARES survival statistics each year in its annual report.

Maryland Resuscitation Academy

The Maryland Resuscitation Academy (RA), a network partner of the Resuscitation Academy in Seattle, put on its inaugural offering in 2012, with the help and support of Seattle faculty, when there was a need for education to save more lives in the eastern US. Over time, the Maryland RA, sponsoring two offerings a year, has successfully completed 35 RAs and educated more than 1,800 graduates in life-saving techniques, travelling to seven states to spread these techniques more broadly.

Focusing on teaching letter-perfect CPR to EMS clinicians, while emphasizing implementation of the Ten Steps to Improve Survival, we have witnessed the power of a team working together to save maximal lives.

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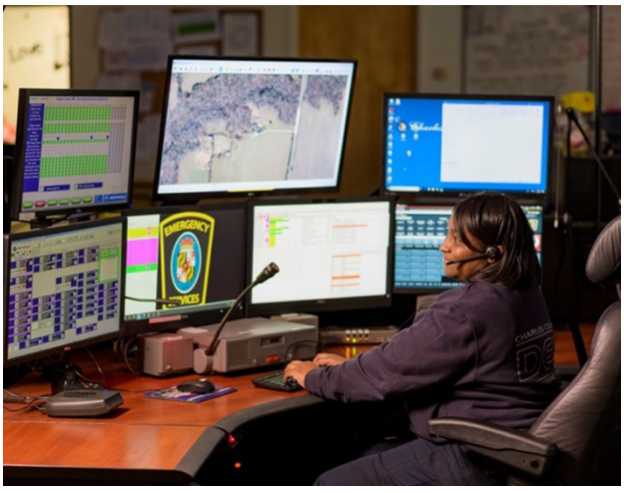
Resuscitation Academy Lighthouse Communities

Lighthouse communities represent "all-star" communities where the focus is resuscitation. They serve as beacons to other communities, providing positive examples of implementing programs to improve survival. In addition, they mentor, teach and share resources so that other communities can improve survival.

Innovation

Over the past three years, pilot programs of two low-dose, high-frequency simulation education programs have been implemented in Charles County, Maryland. Charles County, a southern Maryland D.C. suburb, has a population over 160,000, and responds to more than 30,000 requests for EMS service and 150-200 cardiac arrests per year. Prior to embarking on the pilot, Charles County DES completed the Resuscitation Academy System Assessment, to measure and understand where the baseline for improvement existed. They then undertook the journey to identify opportunities for improvement through implementation. One program, RQI Go, an educational offering for CPR by coaching and measuring CPR performance for 15 minutes every three months, has shown promise by exceeding the AHA metrics for letter perfect CPR. Synergistically, RQI-T for telecommunicators uses similar low-dose, high-frequency simulation via coaches who deliver case-based education on cardiac arrest recognition and convincing callers to deliver chest compressions on victims of cardiac arrest prior to EMS arrival.

Over the period of the pilots, improvements were shown for both EMS clinician CPR performance and telecommunicators' performance on recognition of cardiac arrest and delivery of chest compressions. At the same time, the number of non-traumatic cardiac arrest survivors in Charles County has increased during the pilot innovation.



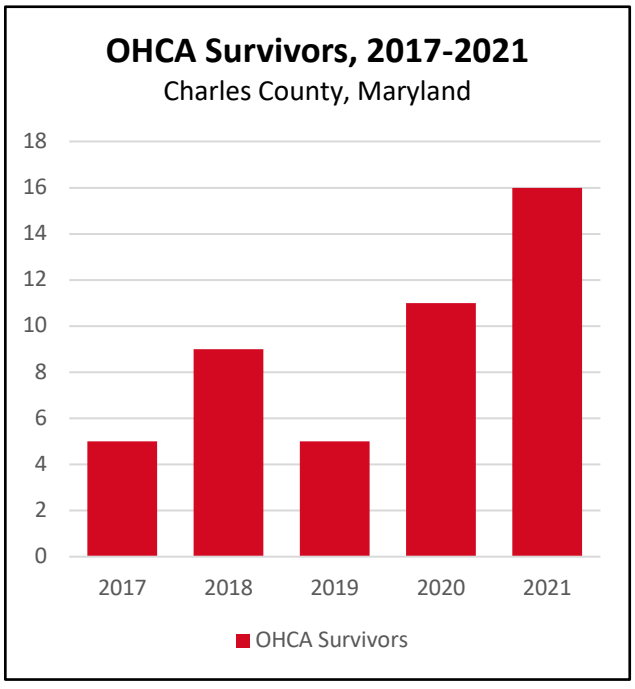
A 911 dispatcher works diligently at her station, answering calls and dispatching help during emergencies.

With expertise in life-saving procedures, a Maryland paramedic demonstrates the intricacies of infant CPR.

Given these promising results, plans are underway to spread these innovative programs to other EMS systems in Maryland. Howard County has begun using RQI Go and early adopter 911 centers are in discussions to pilot RQI-T to implement bystander CPR before EMS arrival. The goal is to maximize survival from cardiac arrest in every community in Maryland.

Measure to Improve

Using CARES to measure enabled us to know where we started at the beginning of our improvement journey. Coming full circle following our implementation, we can use our CARES data to visualize the impact of each survivor on their family, their community, and their workplace.



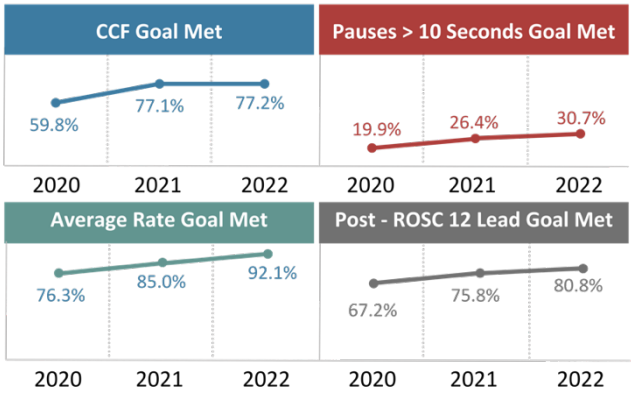
Data Informs Dane County's Pursuit of Improving Sudden Cardiac Arrest Survival

By Eric Anderson, NREMT-P, Emergency Management Data Analyst, Dane County, Wisconsin

It has long been the goal of Dane County EMS (DCEMS) to be a leader in prehospital cardiac arrest resuscitation and survival. We support 23 EMS agencies spanning career, volunteer, urban, rural, ALS, and BLS, and have a team of three physician medical advisors, Dr. Lohmeier, Dr. Kronenfeld, and Dr. VanBendegom. Our County is home to 560,000 residents in over 60 cities, villages, and towns across 1,200 square miles. We average 425 prehospital sudden cardiac arrest (SCA) resuscitations each year, and entered our first CARES case in August of 2016. By the end of 2022 we entered just over 2,400 CARES cases cumulatively.

By 2020, our system had the components to build our SCA improvement process, but lacked a cohesive effort to unify them. There was local interest in improving SCA survival; cardiac monitors capable of gathering resuscitation data; a reporting platform with timely case submission; and an existing relationship with the CARES team to receive year-end outcome reports. As put by Carrie Meier, Deputy Director for DCEM, "As we looked at cardiac arrest, we were able to evaluate our outcomes through the CARES system, but wanted to push further and look at our quality of care and give near-immediate feedback to our providers. This type of feedback has been done in other areas of the Country, but we struggled with making it operational in our system". Through the support of our County Executive and EMS Commission, DCEMS hired a data analyst charged with providing timely and non-punitive feedback to EMS crews on their high-performance resuscitation (HP-CPR) efforts.

Our first step was to implement a model of evidence-based resuscitation by hosting The Resuscitation Academy from King County, WA. From this experience, we set our performance benchmarks: 1) chest compression fraction over 90%; 2) zero pauses lasting longer than 10 seconds; 3) an average compression rate between 100 and 120 beats per minute; and 4) post-ROSC EKG capture on 100% of ROSC patients with five sustained minutes of ROSC without documentation of conflicting priorities. We also knew actionable, consistent, and timely case dissemination would be important factors for success. We were able to establish reliable case identification with a daily automated report from our ImageTrend platform. Access was then gained to each agency's cardiac monitor data, and a summary template was developed. The process of annotating, summarizing, and disseminating case feedback then began. Each summary includes a snapshot of which metrics were achieved, a visual representation of the resuscitation data, and a brief section for feedback on how the cohesive resuscitation went based on the cardiac monitor data and context from the dispatch notes and patient care report (see next page for select summary metrics; full sample feedback report available here).



**visual 1: 2020-2022 n=865. Overall capture rate is 80% of OHCA resuscitations for this timeframe.*

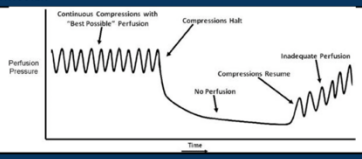
Agency leadership and medical direction receive each summary to share with the involved crews, along with quarterly reports on HP-CPR trends and de-identified peer-to-peer benchmarking. Having both case-specific and peer-to-peer benchmarking allow each agency to perform crew-specific training while evaluating their performance against other departments. At the system level, this information helps identify which agencies could benefit from a local Resuscitation Academy to reinforce our resuscitation priorities. Read more about our specific 2023 HP-CPR goals and year-by-year progress in our January 2023 High-Performance CPR Summary.

Throughout this process, we have seen sustained and marked improvements in each of our metrics (see Figure to the left). At the time of this report's release, over 970 arrest summaries have been distributed. The quality of patient care reports have also become more detailed, giving better context to the review process. I would also like to recognize the efforts of our county-based 911 communications center to improve their T-CPR review process. The impact our telecommunicators have on SCA survival cannot be overstated – their improvement efforts yielded a 62.8% bystander CPR intervention rate in 2022 (a marked increase from 40.2% in 2021).

Our ability to connect this initiative to outcomes is due to partnerships with local healthcare systems and the CARES team. Dr. VanBendegom details the importance of these partnerships - "Seeing our survivor data and comparing it with national standards is a fantastic measure of how we are doing and gives us the information we need to make informed decisions in our care so we can continue to demonstrate improvement." At the forefront of this process is the impact on neurologically intact survival. Based on preliminary data for 2022, Dane County EMS agencies successfully resuscitated 50 patients (excluding overdose etiology), 49 of whom were discharged with a CPC score of 1 or 2. This represents our highest annual number of survivors.

Dane County High Performance CPR Metrics: 3 of 3 Achieved

While no single metric is necessarily more important than another, keep in mind it is the cumulative benefit hitting **all** of these metrics that give each patient the best chance at survival with good neurological outcomes.

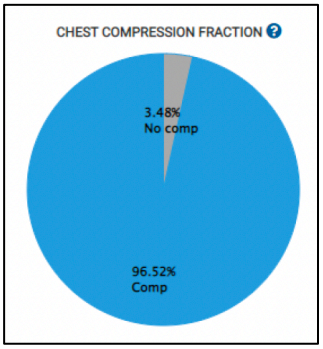
METRIC #1 - Number of Pauses > 10 Seconds	(Goal: 0)
Coronary artery perfusion is directly associated with continuous CPR. It takes approximately 1 minute of compressions to build up effective pressure. Any pause results in an immediate drop of perfusion pressure resulting in longer times of inadequate perfusion. 	✓ Great Work!
METRIC #2 - Chest Compression Fraction	(Goal >90%)
CCF is a metric used to look at the percentage of time chest compressions are happening. An increased CCF is independently associated with improved survival. Our goal is >90% of resuscitation with effective compressions.	✓ 96.52%
METRIC #3 - Average Chest Compression Rate	(Goal: 100 – 120/min)
Excess rate have been shown to decrease depth and consistency, which is essential in high quality CPR. Some providers find it helpful to utilize a metronome and/or QCPR feedback during resuscitation.	✓ Average: 110cpm
METRIC #4 - Post ROSC EKG Obtained?	(Goal: Yes)
One of the most common etiologies of cardiac arrests includes myocardial infarction. Quick recognition of STEMI can lead to emergent intervention, which leads to improved morbidity and mortality. "Time is heart." This metric applies for ROSC lasting at least 5 minutes without documented conflicting priorities (i.e. optimizing hemodynamics & oxygenation).	N/A Pt. Expired in the Field

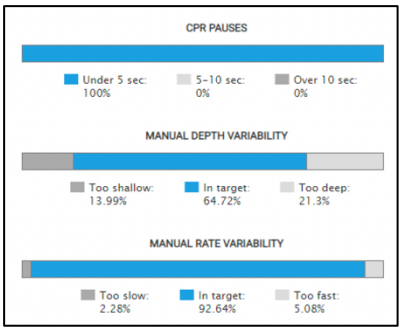
Incident Timeline

A bystander started CPR **2 minutes & 25 seconds** after 911 was dialed.

The initial cardiac rhythm was not shockable.

CPR Performance Summary





Each year, we host an event to recognize our survivors and those who saved their lives. Due to COVID, we combined our 2022 celebration into three years of saves for 2019, 2020, and 2021. In June of 2022, in partnership with the Madison Mallards, we had the privilege of recognizing 118 survivors, each of whom had a team of public safety providers, healthcare systems, 911 professionals, and community members who made this event possible. These celebrations remind providers that success is not impossible, and the improvements we work towards matter.

118 survivors and their dedicated team of public safety providers, healthcare systems, 911 professionals, and community members come together to celebrate three years of saves at Dane County's survivor event, serving as a powerful reminder of the impact of their work in saving lives.

Moving forward, we hope to connect with other EMS systems to share our process and learn how we can continue to improve. If you have questions about our cardiac arrest initiative, please reach out at Anderson.eric@countyofdane.com. Thank you to all our partners within and outside of Dane County for your support, guidance, and tireless commitment to improve neurologically intact survival from cardiac arrest.

Research Highlights

Racial and Ethnic Differences in Bystander CPR for Witnessed Cardiac Arrest

By Paul S. Chan, MD, MSc, Professor of Internal Medicine, Saint Luke's Mid America Heart Institute and the University of Missouri-Kansas City

Bystander cardiopulmonary resuscitation (CPR) increases the odds of survival for patients with out-of-hospital cardiac arrest (OHCA) and is a critical link in the Chain of Survival. However, most cardiac arrest victims do not receive bystander CPR, despite its potential to improve survival and limit anoxic brain injury.

Prior studies have found that Black and Hispanic patients are less likely to survive an OHCA --- this is due, in part, to lower rates of bystander CPR in Black and Hispanic communities. However, prior studies on disparities in bystander CPR have largely focused on differences in CPR rates ***between*** neighborhoods. What has not been well described is the difference in bystander CPR rates between Black/Hispanic and White individuals when examined ***within*** neighborhood. Moreover, whether differences exist only for arrests at home, where relatives and friends are most likely to initiate CPR, or also in public, where there may be more potential bystanders, is unknown.

We set out to understand the magnitude of racial/ethnic differences in bystander CPR for patients with a witnessed OHCA in CARES separately for OHCAs which occurred at home or in public locations. We hypothesized that Black and Hispanic patients with an OHCA would be less likely to receive bystander CPR at home given already known lower rates of CPR training in these communities, but this treatment difference would be smaller for arrests occurring in public, as there are likely more bystanders to initiate CPR.

To do this, we identified 110,054 witnessed OHCAs in patients of White, Black or Hispanic race/ethnicity within CARES between 2013 and 2019. To adjust for confounding, we used hierarchical models so that we could compare bystander CPR rates between Black/Hispanic and Whites individuals with OHCA within each census tract and EMS agency. We examined for differences in CPR rates for OHCAs occurring at home and in public locations.

Of 110,054 witnessed OHCAs, 35,469 (32.2%) occurred in Black (27,205 [24.7%]) or Hispanic (8264 [7.5%]) patients. Overall, 84,296 (76.6%) cardiac arrests occurred at home and 25,758 (23.4%) in public. As compared with White patients, Black/Hispanic patients were less likely to receive bystander CPR at home (38.5% vs. 47.4%; adjusted OR, 0.83 [95% CI: 0.79, 0.87]) and in public (45.6% vs. 60.0%; adjusted OR, 0.76 [0.71, 0.82]). When examined by a neighborhood's race/ethnic composition, bystander CPR rates were lower for Black/Hispanic patients at home and in public locations, whether this was in predominantly White neighborhoods (where >80% of residents are of White race), majority Black/Hispanic neighborhoods (where >50 % of residents are of Black race or Hispanic ethnicity), and integrated neighborhoods (all other neighborhoods in between) – see Table 1. A similar pattern was found for home and public OHCAs when we compared rates of bystander CPR for Black/Hispanic vs. White individuals with OHCA by a neighborhood's income (median household income <$40,000, between $40,000 and $80,000, and > $80,000) – see Table 1. In almost every instance, the racial/ethnic disparity in bystander CPR rates was as large, if not larger for OHCAs occurring in public locations, as compared with those at home— which was contrary to our *a priori* hypothesis.

Finally, we examined bystander CPR rates by public location type. Black/Hispanic patients were less likely to receive bystander CPR in every public location category, including workplace settings (53.2% vs. 61.8%; adjusted OR, 0.82 [0.74, 0.91]), recreational facilities (55.8% vs. 74.4%; adjusted OR, 0.54 [0.42, 0.70]) and public transportation centers (48.3% vs. 69.6%; adjusted OR, 0.50 [0.30, 0.83]) – see Table 2. Notably, the disparity was greatest at the public location where the bystander was most likely a stranger (e.g., transport center or recreational site), even though these sites would have potentially the largest number of potential bystanders who could have initiated CPR.

[3] Garcia RA, Spertus JA, Girotra S, Nallamothu BK, Kennedy KF, McNally BF, Breathett K, Del Rios M, Sasson C, Chan PS. **Racial and Ethnic Differences in Bystander CPR for Witnessed Cardiac Arrest.** *N Engl J Med*. 387(17):1569-1578.

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Table 1. Bystander CPR in Persons with a Witnessed Out-of-Hospital Cardiac Arrest

Event	Black or Hispanic Persons	White Persons	Adjusted Odds Ratio (95% CI)†
	no./total no. (%)		
Overall‡			
At home	10,627/27,573 (38.5)	26,899/56,723 (47.4)	0.74 (0.72–0.76)
In a public location	3604/7896 (45.6)	10,722/17,862 (60.0)	0.63 (0.60–0.66)
Racial or ethnic makeup of neighborhood			
>80% White			
At home	516/1177 (43.8)	11,422/23,286 (49.1)	0.82 (0.74–0.90)
In a public location	313/618 (50.6)	3656/5913 (61.8)	0.68 (0.60–0.75)
>50% Black or Hispanic			
At home	7148/19,143 (37.3)	3306/7616 (43.4)	0.79 (0.75–0.83)
In a public location	1795/4309 (41.7)	1636/2940 (55.6)	0.63 (0.59–0.68)
Integrated			
At home	2963/7253 (40.9)	12,171/25,821 (47.1)	0.78 (0.74–0.81)
In a public location	1496/2969 (50.4)	5430/9009 (60.3)	0.73 (0.68–0.77)
Median household income of neighborhood			
>$80,000			
At home	1637/3662 (44.7)	8120/16,163 (50.2)	0.80 (0.76–0.85)
In a public location	854/1679 (50.9)	3230/5030 (64.2)	0.66 (0.61–0.72)
$40,000–$80,000			
At home	5311/13,026 (40.8)	16,146/34,313 (47.1)	0.82 (0.79–0.85)
In a public location	1712/3617 (47.3)	5946/10,119 (58.8)	0.68 (0.64–0.73)
<$40,000			
At home	3679/10,885 (33.8)	2615/6274 (41.7)	0.74 (0.70–0.78)
In a public location	1038/2630 (39.5)	1546/2713 (57.0)	0.57 (0.54–0.62)

Table 2. Bystander CPR Among Persons with Witnessed Out-of-Hospital Cardiac Arrest in a Public Location

Location	Black or Hispanic Persons	White Persons	Adjusted Odds Ratio (95% CI)*
	no./total no. (%)		
Workplace	2206/4149 (53.2)	6294/10,186 (61.8)	0.73 (0.70–0.77)
Street or highway	891/2800 (31.8)	2167/4555 (47.6)	0.61 (0.57–0.64)
Recreational facility	371/665 (55.8)	1816/2442 (74.4)	0.50 (0.43–0.56)
Public transportation center	73/151 (48.3)	249/358 (69.6)	0.46 (0.37–0.57)
Other	63/131 (48.1)	196/321 (61.1)	0.66 (0.44–0.90)

In summary, we found that Black and Hispanic patients have lower rates of bystander CPR than White patients with OHCA. Compared with White patients, Black and Hispanic patients had 17% lower odds of receiving bystander CPR for arrests at home and 24% lower odds of bystander CPR for arrests in public. These differences were present across all types of neighborhoods, including majority Black/Hispanic communities and low-income communities. Our findings suggest that multifaceted public health interventions that go beyond CPR training may be needed to reduce racial/ethnic differences in bystander CPR.

Several factors could explain lower bystander CPR rates among Black/Hispanic patients at home. CPR training is less commonly conducted in Black and Hispanic communities, and dispatcher-assisted bystander CPR may not be as available. These differences *between neighborhoods* may be due to unequal investments in CPR training and community infrastructure in these neighborhoods. Additional barriers such as cost of CPR training, a different language from dispatchers, immigration status concerns, and/or untrustworthy institutions (e.g., police) could contribute to lower bystander CPR rates *within neighborhoods* for Black/Hispanic patients with OHCAs at home. Racial/ethnic differences in bystander CPR in public locations raise additional concerns about implicit and explicit biases in layperson response. In contrast to a home location, bystanders may not know the victim in public. Implicit bias may deter bystander response for a Black or Hispanic vs. a White cardiac arrest victim. If present, this was not confined to predominantly White communities, as we found racial/ethnic differences in bystander CPR rates in Black/Hispanic and low-income communities. Additionally, explicit bias may contribute to differences in bystander CPR for public arrests, especially at recreational facilities and public transportation centers (e.g., airports and bus terminals), where bystanders were likely strangers.

Our study therefore suggests that multifaceted public health interventions will be needed to reduce racial/ethnic differences in bystander CPR as issues of explicit and implicit bias may influence whether a Black/Hispanic vs. White patient with OHCA receive potentially life-saving CPR from a layperson bystander.

Eligibility of OHCA patients for extracorporeal cardiopulmonary resuscitation in the United States: A geographic information system model

By Adam L. Gottula, MD, Fellow Physician, Emergency Medicine and Anesthesia Critical Care, Michigan Medicine
Cindy H. Hsu, MD, PhD, Assistant Professor, Emergency Medicine and Surgery, Michigan Medicine
Justin L. Benoit, MD, MS, Associate Professor, Emergency Medicine, University of Cincinnati College of Medicine

Despite many recent advances, the survival rate for out-of-hospital cardiac arrest (OHCA) patients in the United States (U.S.) remains low. OHCA treated by emergency medical services (EMS) in the U.S. has a neurologically intact survival to hospital discharge rate of 7.2% with substantial regional variation. The low survival rate of OHCA prompted development of advanced therapies including extracorporeal cardiopulmonary resuscitation (ECPR). In some studies, ECPR has been shown to improve outcomes up to 55% in select patients suffering refractory OHCA. However, ECPR has only demonstrated improved outcomes in select patients, is technically challenging, and only available at select healthcare facilities, thereby limiting its accessibility and feasibility. A strength of the Cardiac Arrest Registry to Enhance Survival (CARES) registry is that it includes clinical characteristics often used to determine ECPR eligibility and the location of the OHCA. We constructed a novel Geographic Information System (GIS) model to estimate the location and number of ECPR candidates in the U.S. using the CARES registry. We additionally determined the time dependent rates of prehospital return of spontaneous circulation (ROSC) in this select population using the Resuscitation Outcomes Consortium Prehospital Resuscitation using an IMpedance valve and Early versus Delayed Analysis (ROC-PRIMED) database.

Our team evaluated 588,203 patients for ECPR eligibility from the CARES registry from 2013–2020. Patients were considered clinically eligible for ECPR if they met the following prehospital criteria: (1) age <65 years old; (2) initial rhythm of ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT); (3) witnessed cardiac arrest; (4) received bystander CPR; (5) a presumed cardiac etiology of arrest; and (6) no ROSC upon arrival to the hospital. In addition to clinical criteria, we applied a GIS model to the CARES registry to model ECPR eligibility based on transportation time to predetermined healthcare centers with the ability to perform ECPR (ECMO-ready centers; with 78.7% of these hospitals reporting adult ECPR). This allowed us to utilize the CARES registry to determine the total volume of OHCA patients that fulfilled ECPR eligibility criteria and met prespecified transportation times to predefined centers.

Patients otherwise clinically eligible for ECPR may achieve ROSC prior to hospital arrival, as several cardiac arrest variables for ECPR eligibility are also associated with higher likelihood of prehospital ROSC. We used the ROC-PRIMED database to model the time-dependent rates of prehospital ROSC and applied the model to patients determined to be ECPR eligible from the CARES registry.

Of the 588,203 patients evaluated in the CARES registry 22,104 (3.76%) patients met clinical eligibility. When transportation time to an ECMO-ready center was accounted for, the ECPR eligible patients in the CARES registry further decreased to 4,466 (0.76%) to 13,828 (2.35%) patients, based on 15- and 45-minute transport times, respectively (Table 1). Finally, after applying the ROC-PRIMED model for time-dependent rates of ROSC the final eligibility was determined to be 4,027 (0.68%) to 9,889 (1.68%) patients, based on 15- and 45-minute transport times, respectively. By utilizing the CARES registry and ROC-PRIMED database to account for proximity to centers with ECMO capabilities and the likelihood of ROSC prior to arrival, respectively, our methods likely provide the most accurate estimation of ECPR eligibility for OHCA patients to date in the U.S.

Time Dependent Rates of ECPR Eligibility based off the ROC-PRIMED OHCA database

	OHCA in CARES Registry	Non-geographic Eligibility*	15-minutes GIS Travel Time**	30-minute GIS Travel Time**	45-minute GIS Travel Time**	15-minutes GIS Travel Time + Time-Dependent Model**	30-minute GIS Travel Time + Time-Dependent Model**	45-minute GIS Travel Time + Time-Dependent Model**
ECMO-Ready Model	588,203	22,104 (3.76%)	4466 (0.76%)	10,785 (1.83%)	13,828 (2.35%)	4027 (0.68%)	8117 (1.38%)	9889 (1.68%)
ECMO-Capable Model			7009 (1.19%)	13,657 (2.32%)	16,497 (2.80%)	6321 (1.07%)	10,624 (1.81%)	12,277 (2.09%)
PCI-Capable Model			13,624 (2.32%)	18,834 (3.20%)	20,413 (3.47%)	12,286 (2.09%)	15,634 (2.66%)	16,558 (2.81%)

Table 1: *(1) initial shockable cardiac rhythm, (2) witnessed arrest, (3) bystander CPR, (4) presumed cardiac etiology of arrest, (5) age ≤ 65. **The percent eligible compared to the total number OHCA in the same period

OHCA=out of hospital cardiac arrest; ECPR=extracorporeal cardiopulmonary resuscitation; CARES=National Cardiac Arrest Registry to Enhance Survival; PCI=Percutaneous Coronary Intervention; GIS= Geographic Information System

While our ECPR eligibility estimation is lower than previously reported, our models still conservatively demonstrate nearly 2,500 potential lives saved over seven years, using 1.68% (9,889/588,203) eligibility from the 45-minute transportation time to an ECMO-ready center model and an assumed 25% survival to hospital discharge with favorable neurologic outcome. Future work utilizing our GIS model and the CARES registry could focus on determining the current access of OHCA patients to ECMO centers based on different population demographics and the effect of alternative ECPR systems of care which could inform future public health planning efforts.

ECMO-ready, ECMO-capable, and PCI-capable GIS Models

Figure 1: Displays the 15-minute, 30 minutes, and 45-minute drive time buffers around (A) ECMO-ready centers (B) ECMO-capable centers and (C) PCI-capable centers in the U.S.

ECMO: Extracorporeal Membrane Oxygenation, PCI: Percutaneous coronary intervention, GIS: Geographic Information System.

[4] Gottula AL, Shaw CR, Gorder KL, Lane BH, Latessa J, Qi M, Koshoffer A, Al-Araji R, Young W, Bonomo J, Langabeer JR, Yannopoulos D, Henry TD, Hsu CH, Benoit JL. **Eligibility of out-of-hospital cardiac arrest patients for extracorporeal cardiopulmonary resuscitation in the United States: A geographic information system model.** *Resuscitation*. 180:111-120.

Incidence & Demographics

2022 Dataset and Incidence of OHCA Events

This report describes CARES data from the most recent calendar year, January 1 to December 31, 2022. 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 2022 National Reports can be viewed at: https://mycares.net/sitepages/reports2022.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 2022 dataset includes 2,317 EMS Agencies and 2,261 Hospitals, and represents a population of 166.4 million, approximately 50% of the U.S. population. In 2022, 147,736 OHCA events were reported to CARES. The crude incidence of non-traumatic, worked arrests was 88.8 per 100,000, slightly lower than the incidence rate of 92.3 per 100,000 observed in 2021. However, this was significantly greater than the average incidence rates observed pre-COVID (range: 74.3-76.5 per 100,000). Using census data to extrapolate to the U.S. population[5], CARES estimates that there were approximately 294,683 EMS-treated, non-traumatic OHCAs in the United States last year.

Demographics

In 2022, CARES patients were predominately male (62.7%). Of the reported OHCA events, 97.3% (n=143,769) were adults and 2.7% (n=3,916) were children, 18 years and younger. The median age of OHCA patients was 65.0 years (mean: 62.2; SD: 19.3). The age distribution varied significantly across the sexes (Figure 2), with females having a higher median age of arrest (67.0 vs 64.0 years, p<.0001).

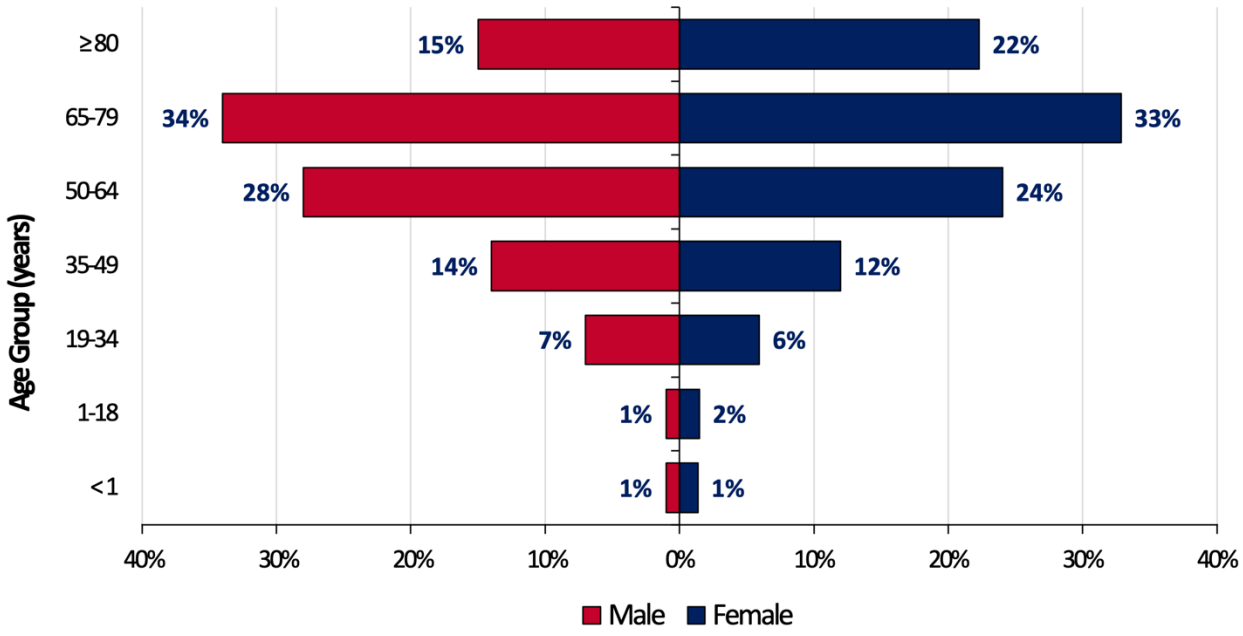

Figure 2. Age distribution of OHCA events.

[5] 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[2], 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 2022, 82.5% of adult (>18 years of age) OHCAs were presumed to be of a cardiac cause. Other causes of adult OHCA were: respiratory/asphyxia (8.7%), drug overdose (7.0%), exsanguination/hemorrhage (0.7%), drowning/submersion (0.5%), and other medical (0.6%) (Figure 3).

The etiology of arrest for pediatric patients (≤18 years of age) differed substantially from that of adults. In 2022, 42.0% of pediatric arrests were presumed to be of a cardiac etiology. Other causes of pediatric OHCA were: respiratory/asphyxia (38.3%), drowning/submersion (8.0%), drug overdose (6.4%), SIDS/SUID (3.1%), and other medical (2.2%) (Figure 4).

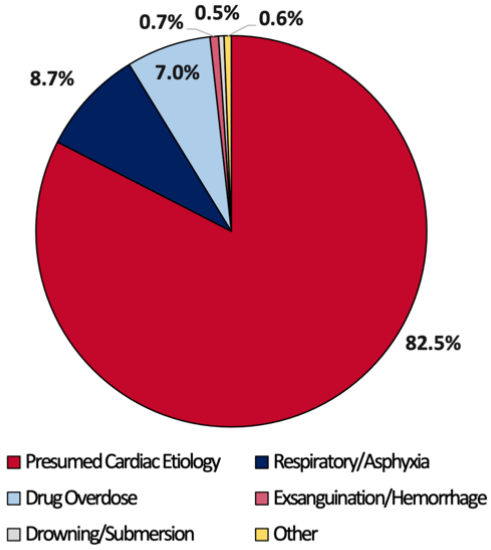

Figure 3. Etiology of arrest for adults.

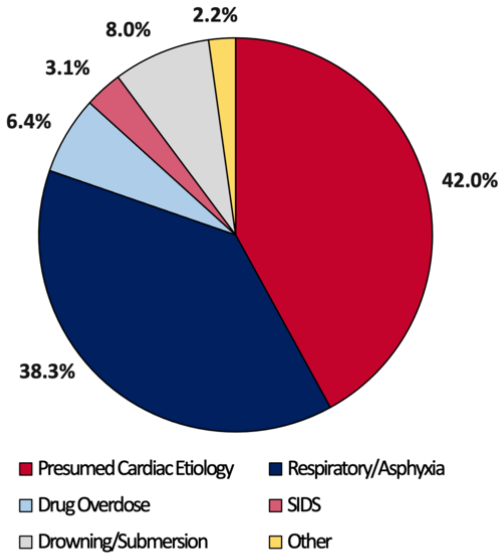

Figure 4. Etiology of arrest for pediatric patients.

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 37.1% of arrests in the 19-34 age group and 20.1% of arrests in the 35-49 age group, highlighting the impact of the current opioid epidemic in the United States.

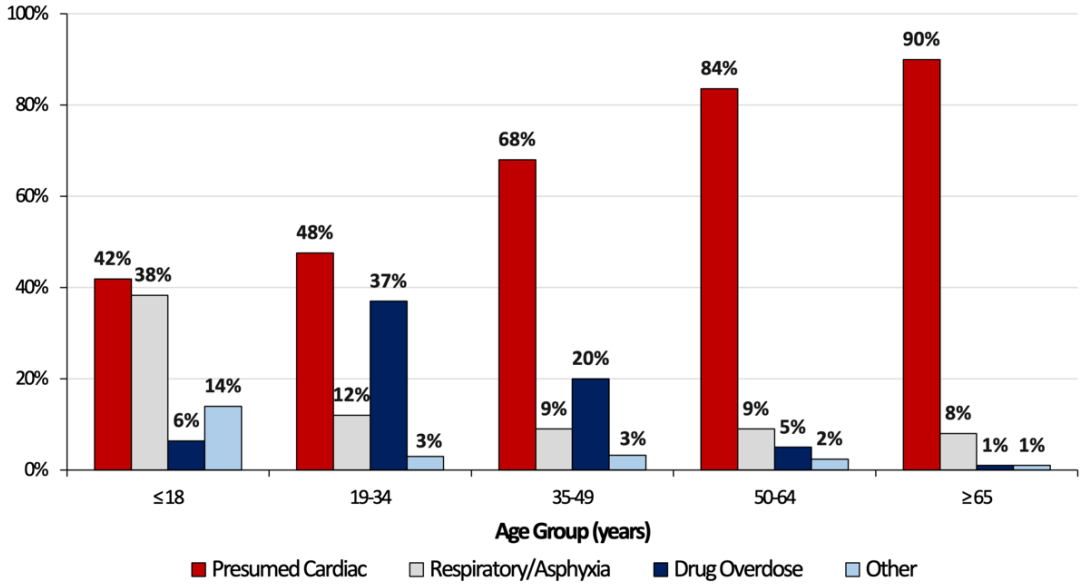

Figure 5. Etiology of arrest by age group.

Location of Arrest

The most common place for an OHCA to occur is in a residential setting, with 72.4% of events occurring in a home. Other common arrest locations were nursing home (10.3%), public or commercial building (7.2%), street or highway (4.8%), and healthcare facility (3.0%) (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 2.4-fold rate of survival to hospital discharge compared to residential arrests (18.9% vs 7.9%, respectively; p< .0001).

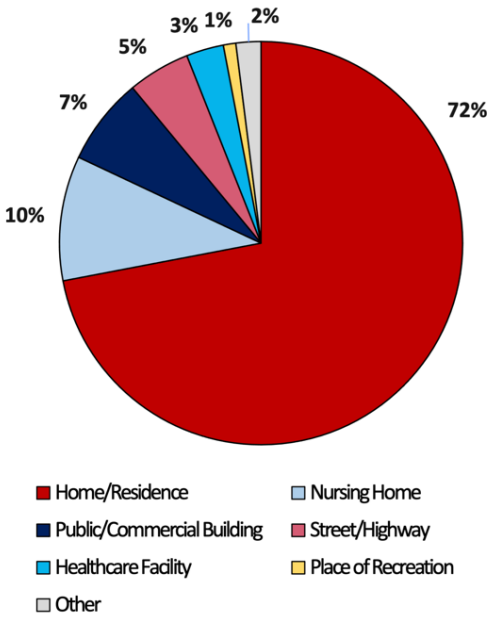

Figure 7. Location of Arrest

Denver Health Paramedics (Colorado) take to the streets on bicycles to provide fast and efficient emergency response services.

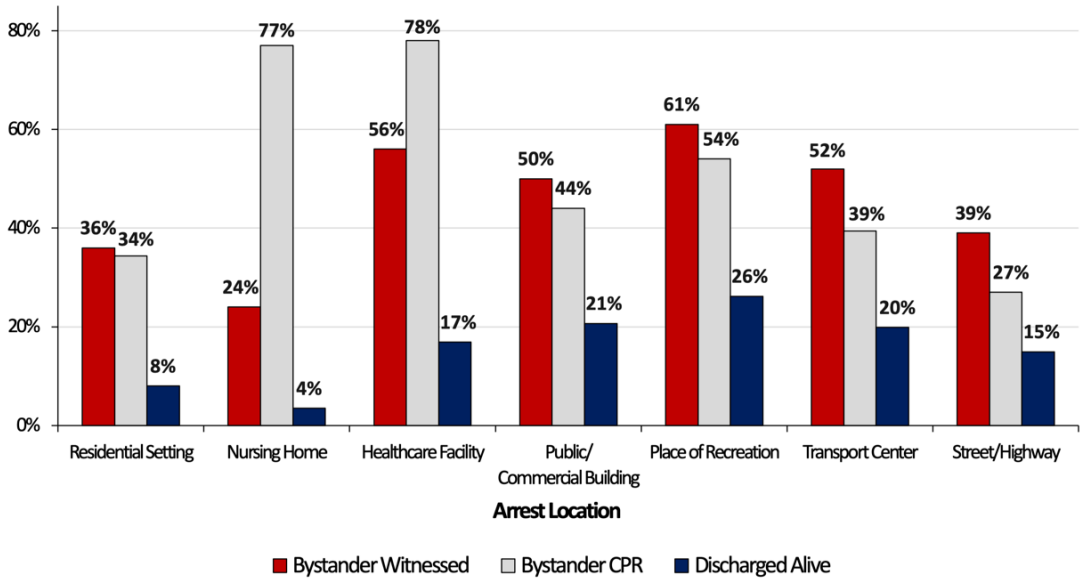

Figure 6. Percentage of events that are bystander witnessed, receive bystander CPR, and survive to hospital discharge by arrest location.

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 (51.3%), while 37.1% were bystander witnessed and 11.6% 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 (14.2% vs 4.1%, respectively; p<.0001), while patients with a 911 Responder witnessed arrest were approximately 4 times as likely to survive compared with unwitnessed arrests (17.1% vs 4.1%, respectively; p<.0001).

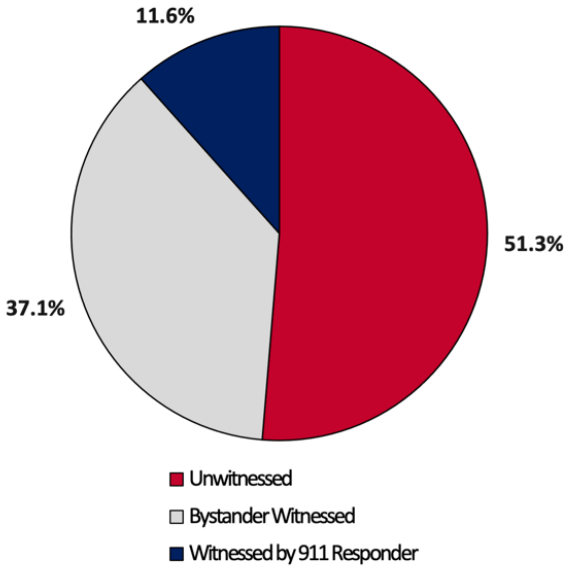

Figure 8. Arrest witness status.

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 (26.8% vs 5.8%, p<.0001).

17.0% of patients presented with an initial shockable rhythm of ventricular fibrillation (VF) or ventricular tachycardia (VT), while 83.0% of patients presented in an unshockable rhythm, with asystole being the most common (52.7%). 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 (27.5% vs 9.4%, respectively; p<.0001) (Figure 9).

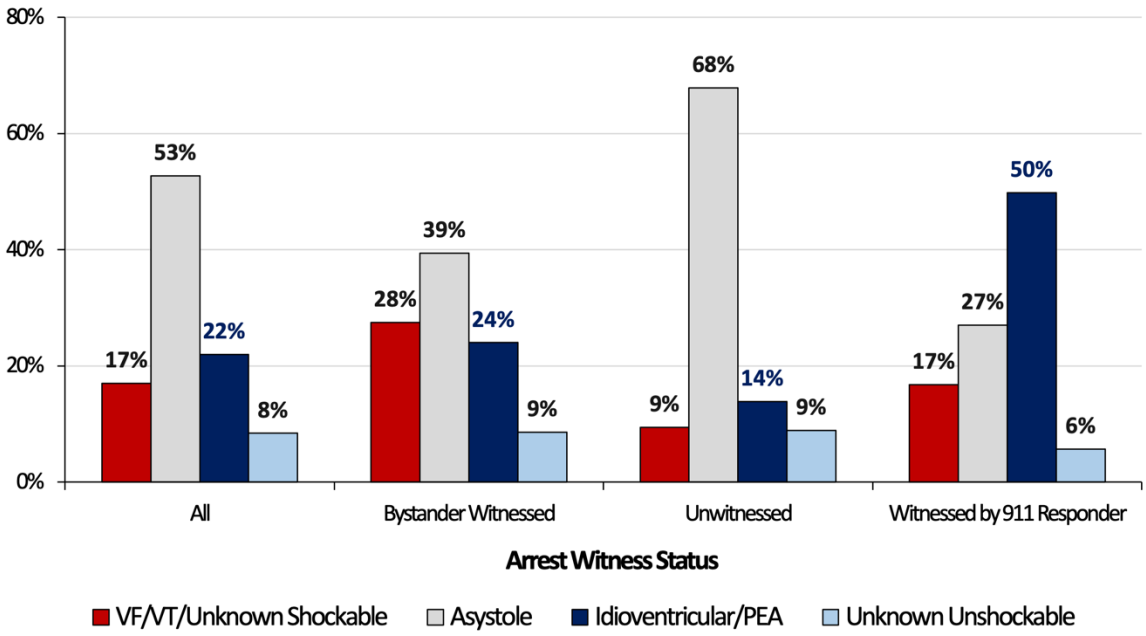

Figure 9. Presenting arrest rhythm by arrest witness status.

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%[6]. 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 (15.6%) as well as those that were witnessed by a 911 Responder (11.6%), have been excluded from response time analyses.

In 2022, median response time by First Responders was 6.4 minutes (IQR: 5.0 - 8.6 minutes) and median response time by EMS was 7.8 minutes (IQR: 5.8 - 10.7 minutes). First Responders arrived on scene in ≤ 5 minutes for 27.7% of arrests, while EMS arrived on scene in ≤ 9 minutes for 63.2% of arrests.

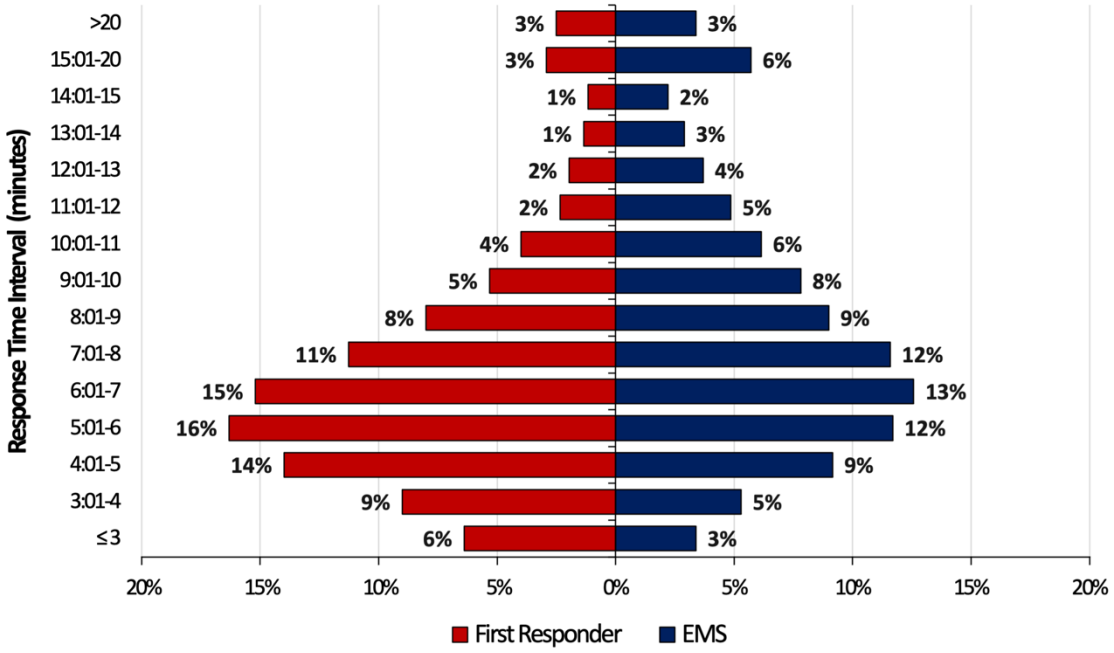

Figure 10. Distribution of First Responder and EMS response times (time interval from 911 call to arrival on scene).

[6] 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.

01

Activation of Emergency System

Community Ambulance (Nevada)

02

Early CPR

Orange County Fire Rescue Department (Florida)

03

Early Defibrillation

CoxHealth EMS (Missouri)

04

Rapid Delivery of EMS Care

Baytown Fire & Rescue Services (Texas)

Howard County Department of Fire and Rescue Services (Maryland)

Lincoln County EMS (Nebraska)

Empowering communities with life-saving skills, one CPR course at a time

Youth community CPR courses are becoming increasingly recognized as a valuable tool in promoting public safety and empowering young people to respond to sudden cardiac arrest situations. By providing young people with the skills and knowledge needed to perform CPR, these courses create a sense of community responsibility and empowerment in the next generation. In addition to saving lives, youth community CPR courses promote a culture of preparedness and contribute to building safer and more resilient communities.

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.

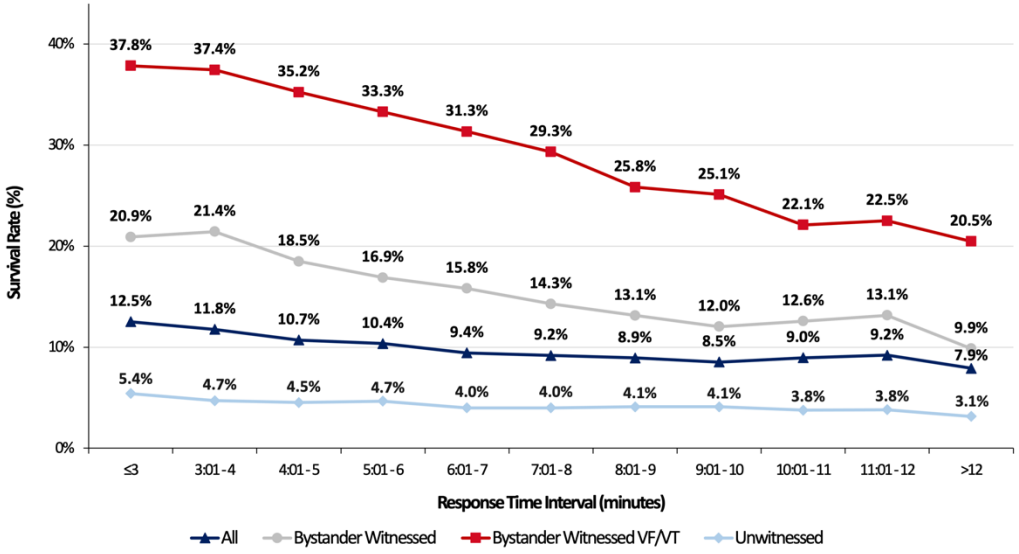

Figure 11. Survival rate by EMS response time and arrest witness status.

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.

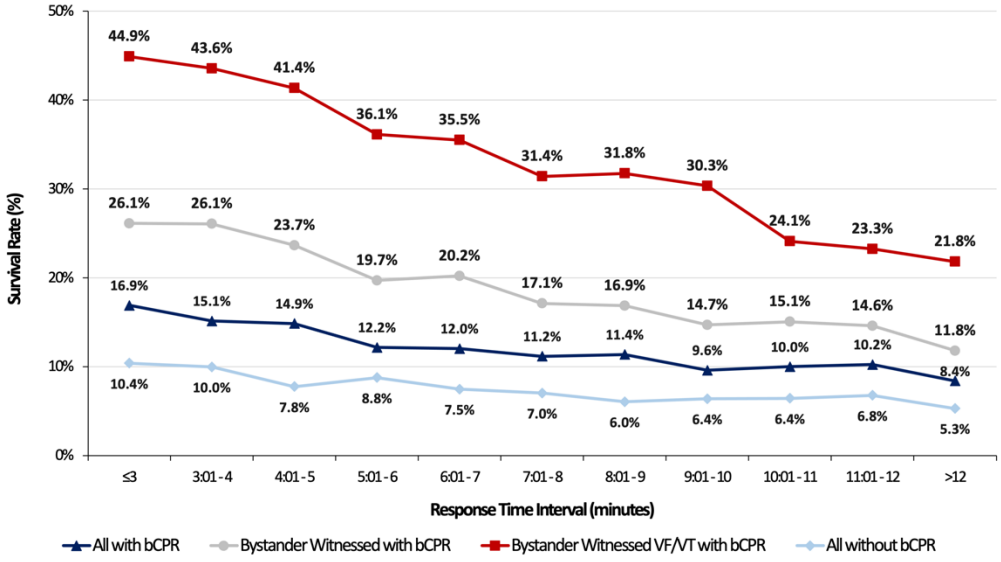

Figure 12. Survival rate by EMS response time and arrest witness status, among patients who received bystander CPR.

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 2022, bystander CPR was initiated on 40.0% 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 48.0% of bystander witnessed events, compared with 33.9% of unwitnessed events (p<.0001).

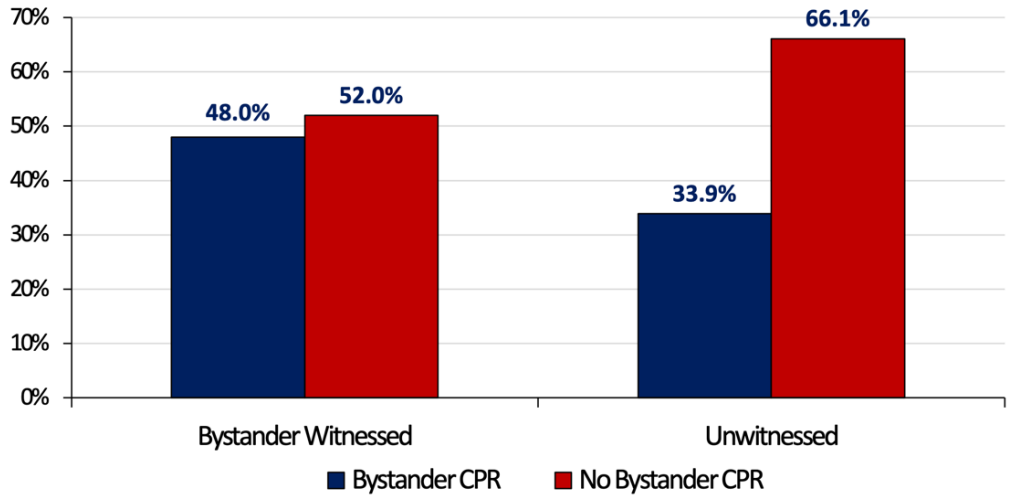

Figure 13. Bystander CPR provision by arrest witness status.

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 (11.3%) was significantly (p<.0001) higher than that of patients who did not receive bystander CPR (7.0%).

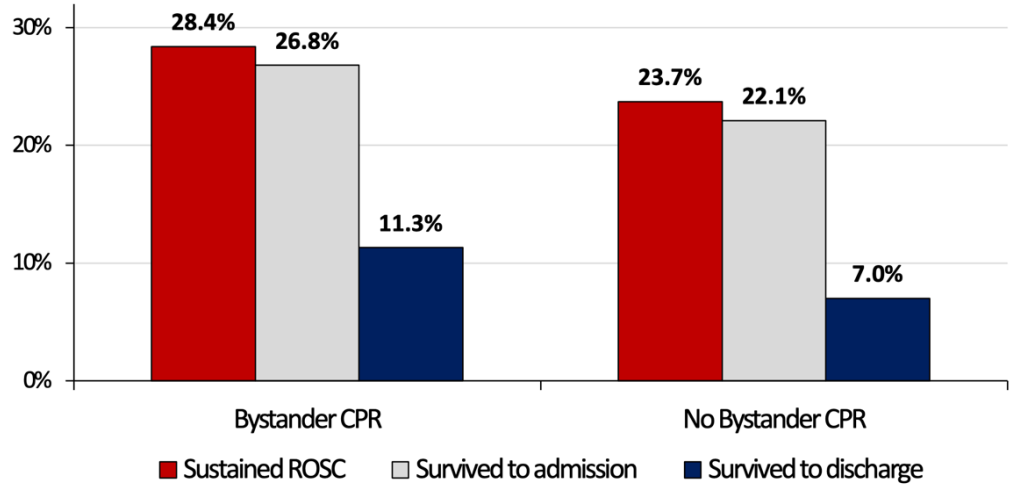

Figure 14. Unadjusted survival outcomes after bystander CPR.

Early Defibrillation

More than 14% 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 11.3% of public arrests.

In 2022, 29.1% (n=42,968) of CARES patients were defibrillated in the field. The proportion of patients first defibrillated by a bystander was 5.2%, whereas 21.2% and 73.6% 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 44%, compared with 25% of patients first shocked by a first responder or responding EMS personnel.

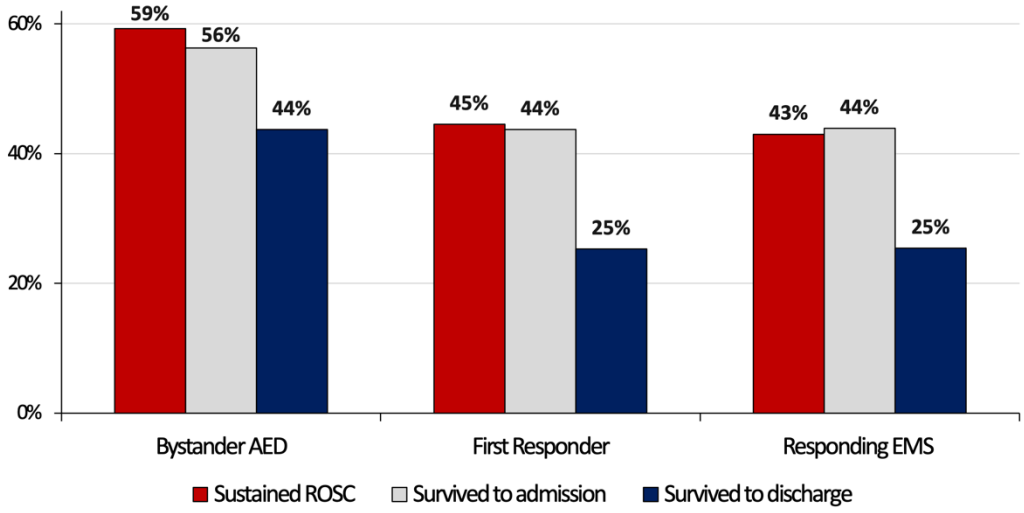

Figure 15. Unadjusted survival outcomes by who performed first defibrillation in the population with a shockable presenting rhythm.

Lt. John Whitehead, an Atascocita Fire Department (Texas) Firefighter/EMT, holds his daughter while being honored at a cardiac arrest "Saver Reunion".

Survival Outcomes

Patient Outcomes

On the basis of local EMS agency protocols, 44.0% 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 2022, sustained ROSC (20 consecutive minutes of ROSC, or present at transfer of care to a receiving hospital) was achieved by 26.7% of CARES patients.

The rate of survival to hospital admission was 24.9% (ED outcome missing for 287 cases; 0.2%), and the rate of survival to hospital discharge was 9.3% (hospital outcome missing for 291 cases; 0.2%). 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).

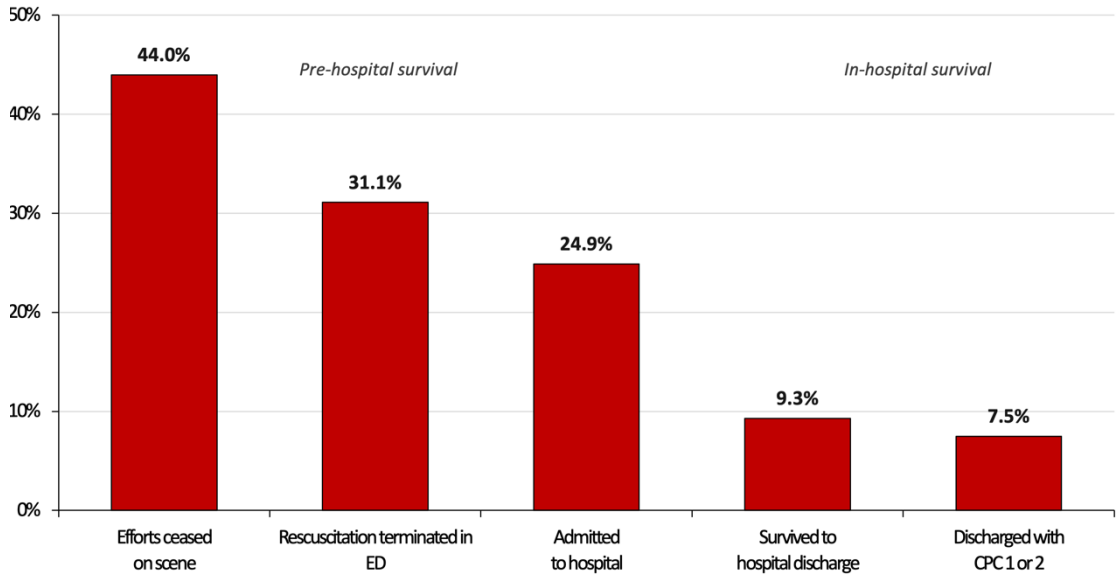

Figure 16. Unadjusted pre-hospital and in-hospital OHCA patient outcomes.

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 8.4%. Survival among patients with an arrest caused by a respiratory mechanism or drowning was slightly higher (11.6 and 10.3%, respectively), whereas patients with an overdose-related arrest had a survival rate of 16.3%. Survival was lowest among patients with an arrest due to exsanguination or hemorrhage (3.4%) (Figure 17).

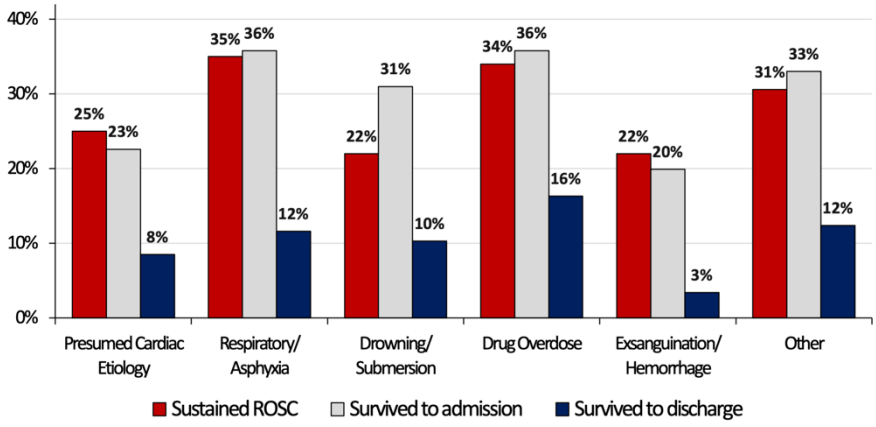

Figure 17. Unadjusted survival outcomes by arrest etiology.

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 44.7%, compared with 32.6% for those in PEA and 14.5% for those in asystole. Similarly, patients presenting in a shockable rhythm had a greater chance of being discharged alive (26.6%), compared with 10.5% of patients presenting in PEA and 2.3% of patients in asystole.

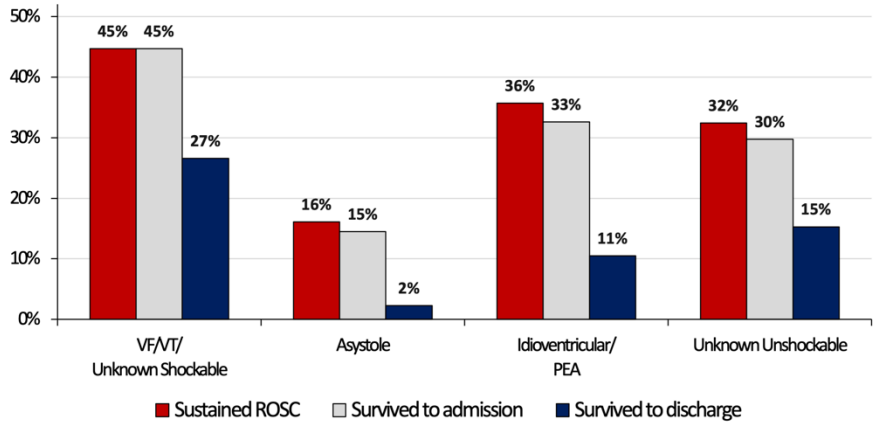

Figure 18. Unadjusted survival outcomes by presenting arrest rhythm.

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 (17.1%), followed closely by those with a bystander witnessed arrest (14.2%). In contrast, unwitnessed events had a survival rate of 4.1% (Figure 19).

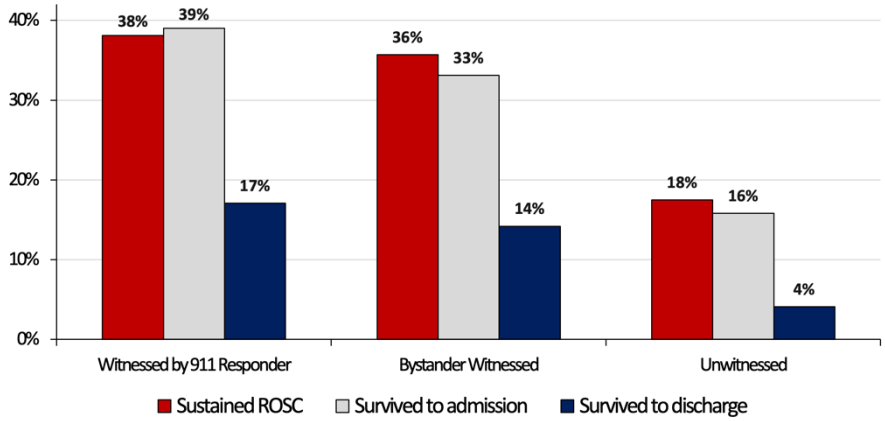

Figure 19. Unadjusted survival outcomes by arrest witness status.

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 2022. This report stratifies arrests by witness status and presenting rhythm. In 2022, the survival to hospital discharge rate for the Utstein subgroup was 30.7%. 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 34.3%.

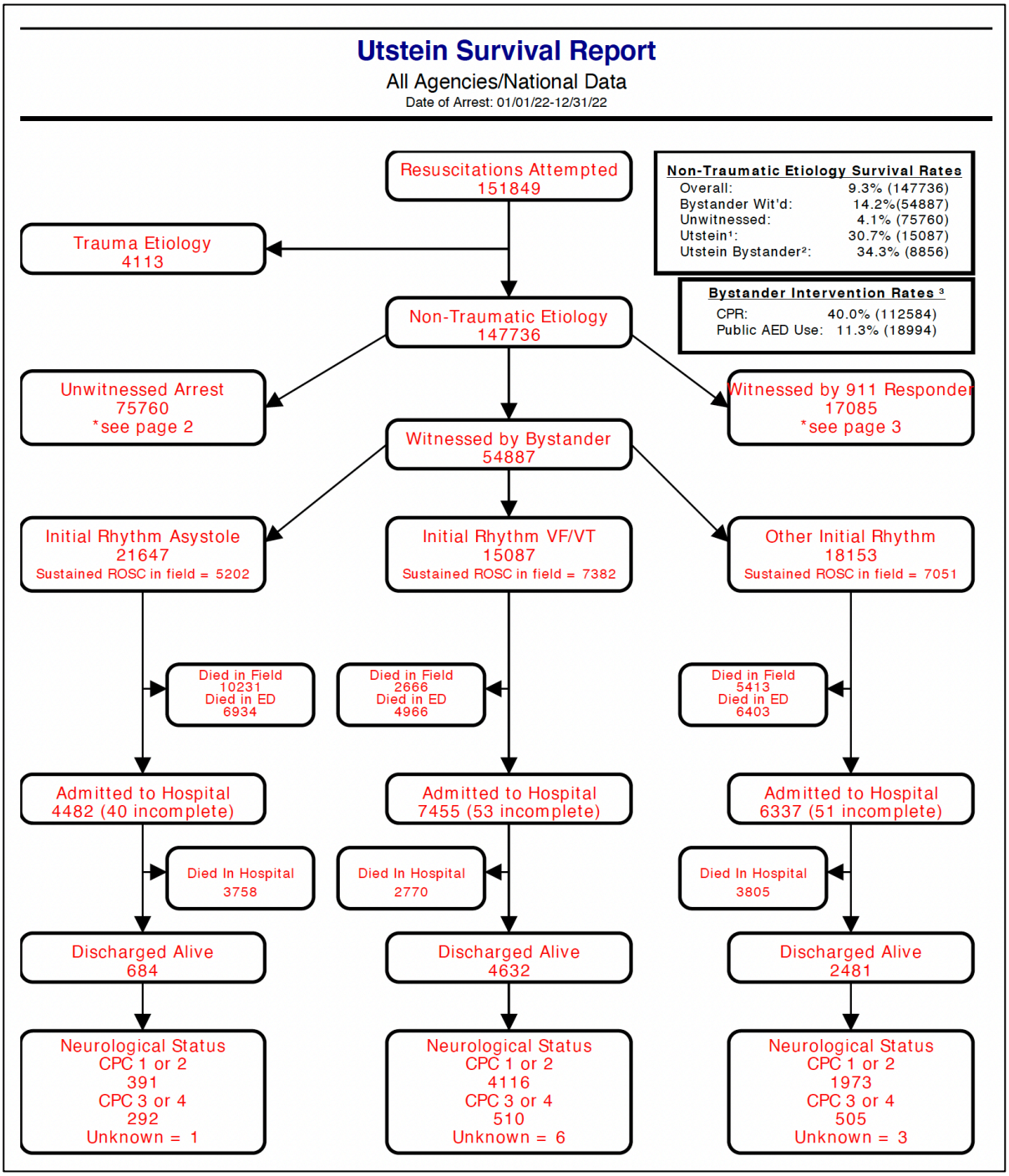

Figure 20. 2022 CARES Non-Traumatic Etiology Utstein Survival Report.

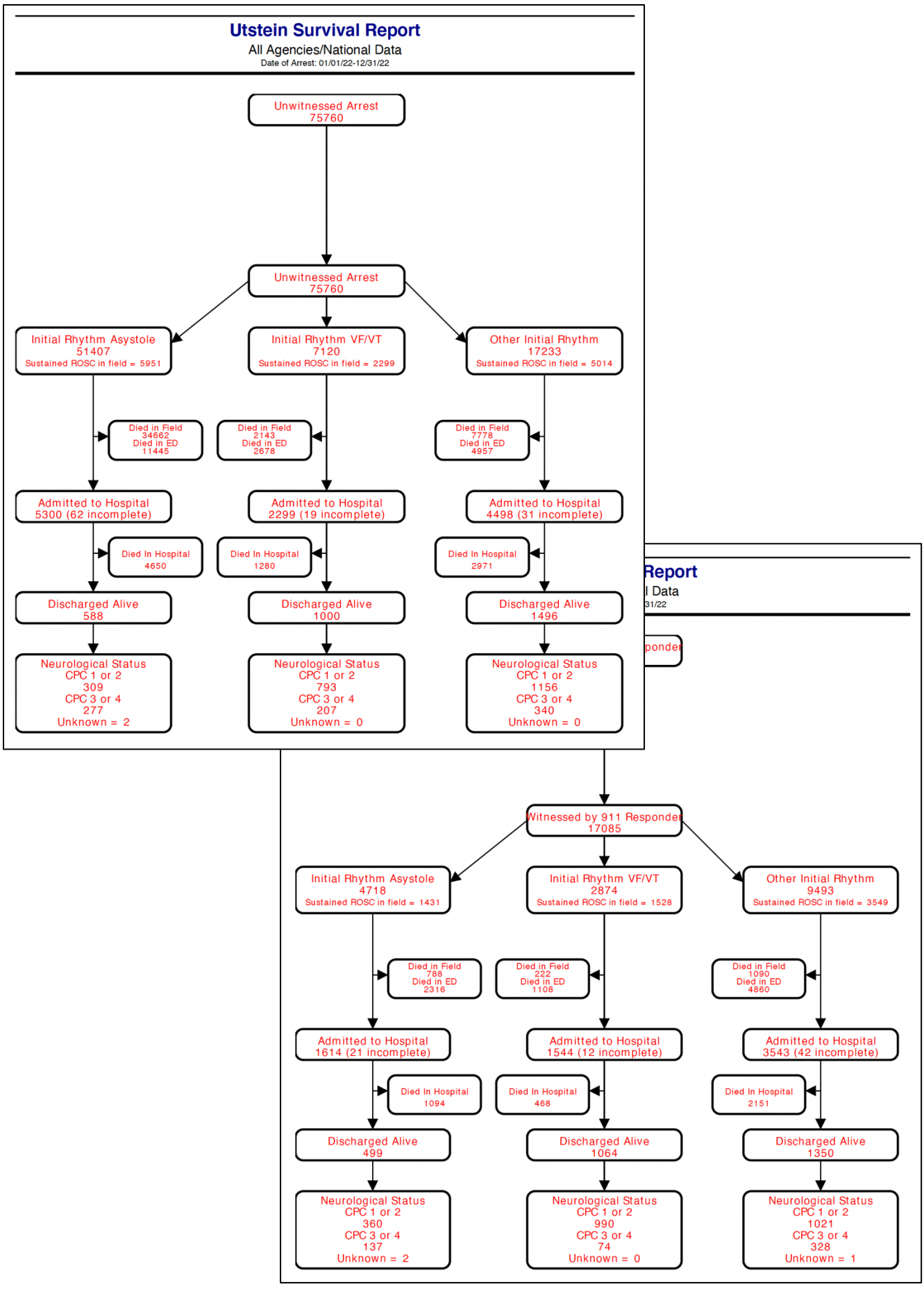

Figure 20. 2022 CARES Non-Traumatic Etiology Utstein Survival Report.

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 2022.

Among all patients transported to a hospital, the survival to admission rate was 44.5% and the survival to discharge rate was 16.7%. Survival to hospital discharge was substantially higher among those who achieved sustained ROSC in the field (32.1%) compared with those who did not (2.8%), and among those who were transferred from another facility (45.6%) compared with patients who were transported directly by EMS (15.2%).

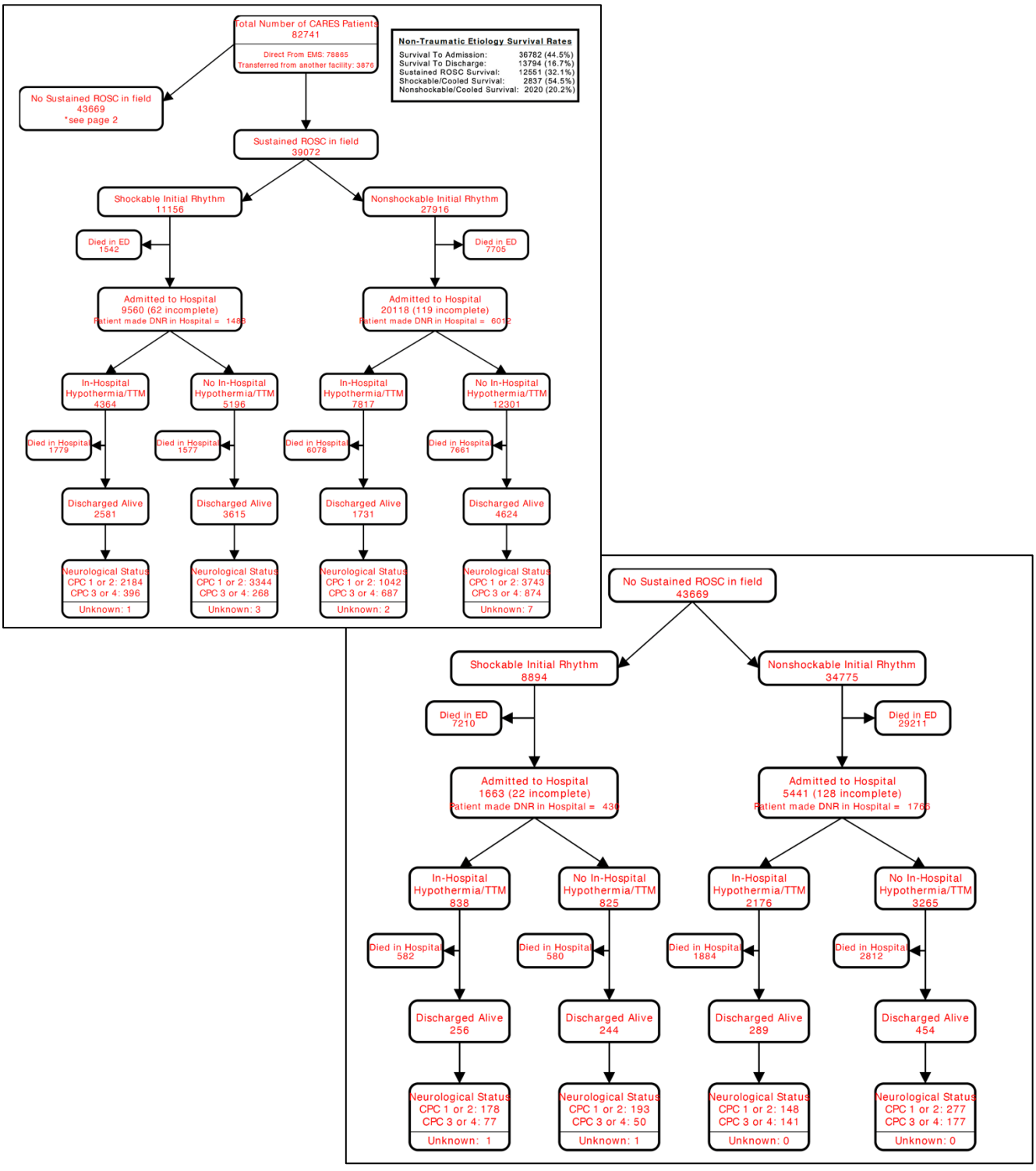

Figure 21. 2022 CARES Non-Traumatic Etiology Hospital Survival Report.

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 178 EMS agencies with ≥200 CARES cases in 2022. These figures highlight the significant variability among participating agencies (ranges: overall survival 2.4–18.1% (more than 7-fold difference); Utstein survival 0.0–66.7%; bystander CPR 14.9–80.0% (more than 5-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: 9.3%; Utstein survival: 30.7%; bystander CPR: 40.0%), while the grey vertical lines indicate quartile cut points.

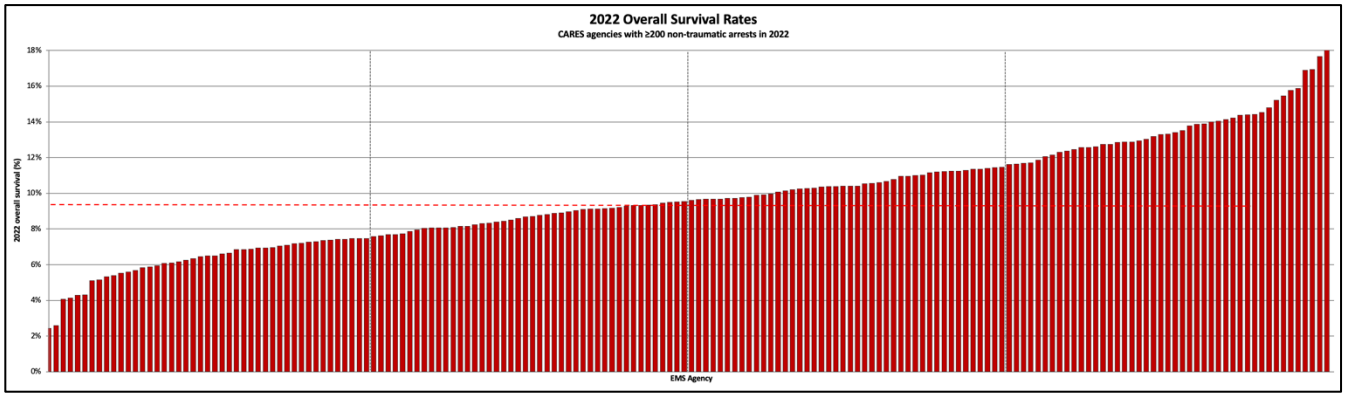

Figure 22. Variability in overall survival rates, among EMS agencies with ≥200 CARES cases in 2022.

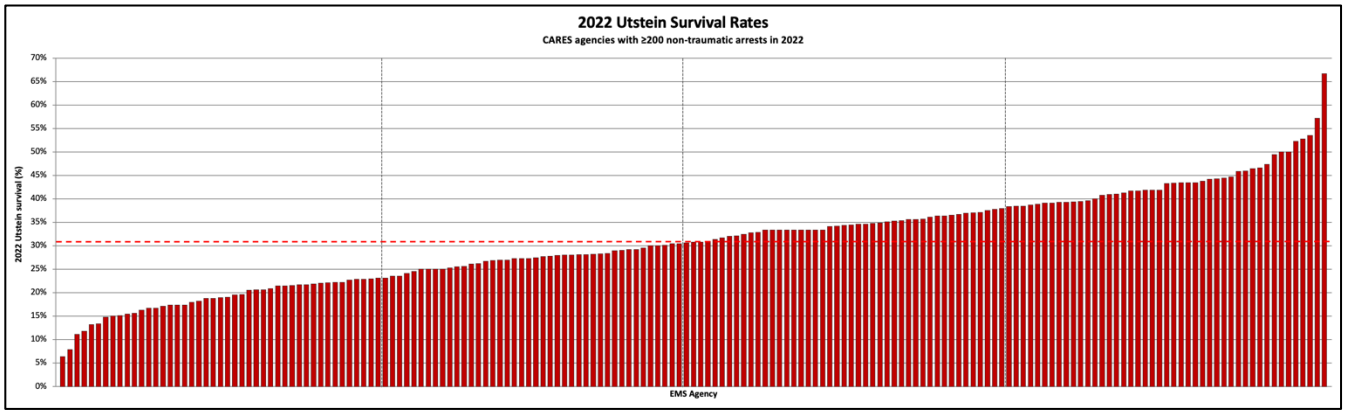

Figure 23. Variability in Utstein survival rates, among EMS agencies with ≥200 CARES cases in 2022.

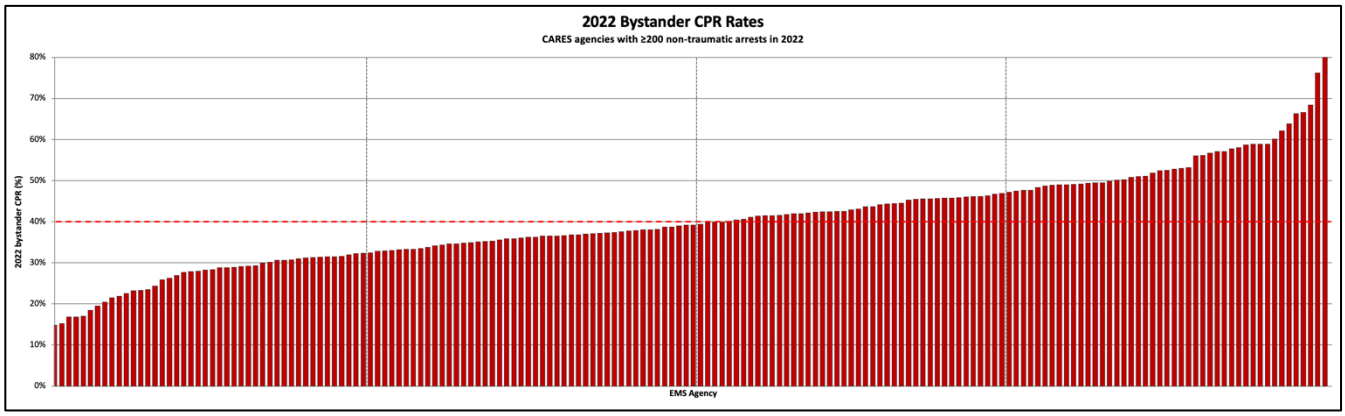

Figure 24. Variability in bystander CPR rates, among EMS agencies with ≥200 CARES cases in 2022.

In 2022, CARES reported 13,794 out-of-hospital cardiac arrest survivors.

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 2022. 19 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 (608,301 to over 32 million) as well as incidence rate (49.9–131.3 per 100,000; a 2.6-fold difference). There was also marked variability in community interventions, with bystander CPR rates ranging from 22.8–73.2% (a 3.2-fold difference) and public AED use rates ranging from 6.0–18.8% (a 3.1-fold difference), as well as patient outcomes (overall survival: 5.5–15.4%; Utstein survival: 20.0–42.5%).

Table 4. Public Reporting of State Aggregate Metrics, 2022

	OHCA Incidence					Non-Traumatic Etiology Survival Rates		Bystander Intervention Rates	
	CARES Cases Reported	CARES Population Catchment	Total State Population	% Population Covered	Incidence Rate (per 100,000)	Overall Survival to Hospital Discharge (%)	Utstein Survival (%)	CPR (%)	Public AED Use (%)
National	**147,736**	**166,391,259**	**331,893,745**	**50.1%**	**88.8**	**9.3**	**30.7**	**40.0**	**11.3**
State									
Alaska	542	608,301	732,673	83.0%	89.1	12.7	42.5	73.2	18.8
California	26,403	32,866,592	39,237,836	83.8%	80.3	7.8	28.6	41.0	9.6
Colorado	3,711	4,581,690	5,812,069	78.8%	81.0	11.6	35.2	38.8	13.9
Connecticut	2,480	2,656,834	3,605,597	73.7%	93.3	9.5	34.0	22.8	6.0
Delaware	1,317	1,003,384	1,003,384	100.0%	131.3	10.6	41.5	37.0	9.0
Hawaii	1,693	1,441,553	1,441,553	100.0%	117.4	10.9	38.2	37.4	10.4
Maine	1,363	1,372,247	1,372,247	100.0%	99.3	7.6	20.1	52.2	14.6
Michigan	9,275	8,775,764	10,050,811	87.3%	105.7	8.1	25.2	35.6	9.1
Minnesota	3,293	4,701,076	5,707,390	82.4%	70.1	10.1	33.3	37.9	11.4
Mississippi	1,695	1,884,391	2,949,965	63.9%	89.9	6.3	23.8	38.7	9.9
Missouri	3,134	3,228,811	6,168,187	52.3%	97.1	10.0	35.9	40.0	15.4
Montana	660	977,094	1,104,271	88.5%	67.5	11.2	26.0	50.0	6.1
Nebraska	701	1,101,328	1,963,692	56.1%	63.7	15.4	37.4	50.1	12.0
North Carolina	9,117	9,224,576	10,551,162	87.4%	98.8	10.8	29.3	38.8	11.1
Oregon	2,940	3,569,007	4,246,155	84.1%	82.3	14.6	40.6	56.9	12.9
Utah	1,666	3,337,975	3,337,975	100.0%	49.9	10.2	32.5	37.2	9.2
Vermont	547	645,570	645,570	100.0%	84.7	5.5	20.0	48.7	14.6
Washington	5,342	7,581,064	7,738,692	98.0%	70.5	12.6	35.8	51.7	11.3

Table 4. Public Reporting of State Aggregate Metrics, 2022.

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.

[7] Annual Estimates of the Resident Population: April 1, 2020 to July 1, 2021 Source: U.S. Census Bureau, Population Division

Data Linkage: Maximizing the Value of Public Health Data

There are numerous entities in the United States responsible for creating and maintaining health records, including government agencies and private institutions, as well as individual researchers. The use of data silos - where data is created, stored, and analyzed in separate systems - is common. However, this fragmentation of data presents challenges in answering critical public health questions. To facilitate high-quality research and evaluation, it is important to integrate datasets and gather information from various secondary data sources, such as environmental and social data, to gain a more comprehensive understanding of the complex factors that influence out-of-hospital cardiac arrest (OHCA) and overall public health.

The variables collected by CARES, such as geographic information, and patient information, such as age, sex and date of arrest, allow for robust linkage of registry data with other datasets, enabling researchers to answer questions regarding OHCA not readily available. One method of matching records from separate databases is to use the 'deterministic method', where unique identifiers are used for linkage. However, it is not always possible to directly link records due to insufficient identifying information or concerns related to confidentiality. In such situations, 'probabilistic matching', which uses a statistical approach to measure the likelihood that two patient records represent the same person, can be applied.

Urbanicity Data Linkage

The CARES dataset is geocoded on an annual basis and linked to a number of census-tract level variables including median household income, poverty status, urbanicity, and educational attainment. By analyzing data linked to census-level information, researchers were able to investigate the impact of bystander cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) use on survival rates across urban and rural settings. Despite a higher proportion of arrests that were witnessed and received bystander interventions within non-urban areas, OHCAs which occurred in suburban, small town, and rural areas had poorer clinical outcomes than urban and large rural areas (Table 1). This study emphasized that the likelihood of receiving bystander interventions and the probability of favorable clinical outcomes after OHCA differ across the urban-rural spectrum. By tailoring intervention strategies to the unique needs of each community, including addressing challenges related to urban-rural differences in care and outcomes, we can strive to improve OHCA survival rates and clinical outcomes in all settings.

Table 1. Outcomes of the study population in areas along the urban–rural spectrum**.**

	Total	Urban	Suburban	Large Rural	Small Town	Rural
	N = 325,477	*N* = 271,640	*N* = 15,790	*N* = 14,033	*N* = 13,078	*N* = 10,936
Sustained ROSC	99,766	84,483	4,659	4,460	3,625	2,539
	(30.7%)	(31.1%)	(29.5%)	(31.8%)	(27.7%)	(23.2%)
Missing, *N*	95	92	0	2	0	1
Survival to Hospital Admission	88,680	76,604	3,722	3,641	2,778	1,935
	(27.3%)	(28.3%)	(23.6%)	(26.0%)	(21.3%)	(17.8%)
Missing, *N*	859	682	36	51	44	46
Survival to Hospital Discharge	32,019	27,374	1,389	1,457	1,063	736
	(9.9%)	(10.1%)	(8.8%)	(10.4%)	(8.2%)	(6.8%)
Missing, *N*	898	715	38	52	46	47
Survival with CPC 1 or 2	25,982	21,907	1,208	1,277	927	663
	(8.0%)	(8.1%)	(7.7%)	(9.1%)	(7.1%)	(6.1%)
Missing, *N*	1,393	1,194	41	56	53	49

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Environmental Data Linkage

Linking CARES data with environmental data allowed researchers to assess the association of acute exposure to ambient air particulate matter and ozone with risk of OHCA. Data from the CARES registry was combined with ambient air temperature data retrieved from the North American Regional Reanalysis using the deterministic method, linking by zip code. Malik et al. found that exposure to higher levels of ambient air ozone on day of arrest, but not particulate matter < 2.5 µm ($PM_{2.5}$), was associated with a higher risk of cardiac arrest (Figure 1). The results highlight the importance of understanding the dose-response relationship of ozone with risk of OHCA to inform policy on monitoring ambient air levels in the U.S.

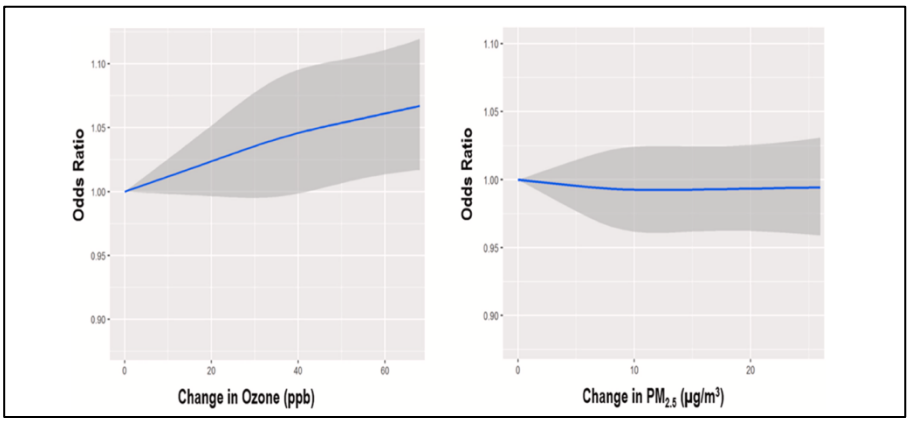

Figure 1. Dose-response relationship between $PM_{2.5}$ and Ozone levels from control day to case day and risk of OHCA on a continuous scale. (Results are adjusted for temperature).

Figure used with permission of Elsevier from Malik A et al. Association of ambient air pollution with risk of out of hospital cardiac arrest in the United States. AHJ Plus: Cardiology Research and Practice. 17: 100151 (2022). Permission conveyed through Copyright Clearance Center Inc.

Medicare Data Linkage

Numerous registries have reported on layperson response and outcomes for OHCA, but data on long-term survival, hospital readmission, and costs for arrest survivors are limited. To examine this, CARES data were linked to data from Medicare, the largest insurer in the United States (fee-for-service Medicare) using probabilistic matching algorithms. The identifiers used included patient age and sex, admission date, admitting hospital, and a qualifying International Classification of Diseases, Ninth Revision or Tenth Revision, Clinical Modification diagnosis or procedure code. Analysis of the linked dataset found that for older individuals who had survived their cardiac arrest, approximately one out of three died within the first year following the arrest, and readmissions were common. Figure 2 represents Kaplan-Meier estimates for 5-year survival among those discharged alive from an out-of-hospital cardiac arrest for the overall cohort (A) and by discharge destination (B). Following hospital discharge, the mortality rate was initially high (27.0% at 3 months) and rose gradually over time. The estimated mortality rate at one and three years after discharge were 37.1% and 50.1%, respectively. During the first year, 40.1% of patients were readmitted to the hospital at least once, with 19.7% readmitted on more than one occasion. The linked dataset utilized in the study offers a unique opportunity to gain insights into the long-term outcomes of OHCA survivors, which is not readily available within the CARES dataset.

Data linkage also allows for validation across datasets. Using the CARES-Medicare dataset, researchers examined the concordance of race/ethnicity in CARES with self-reported race/ethnicity in Medicare (Table 2). The concordance rate for race/ethnicity between CARES and Medicare was high for non-Hispanic White patients (93.4%), followed by non-Hispanic Black patients (89.1%). However, the concordance rate was slightly lower for other ethnic groups -- 74.6% for Hispanics, 69.6% for Asians and Pacific Islanders, and 37.8% for American Indian or Alaskan Natives. For patients with unknown race/ethnicity in CARES, the majority (69.0%) identified themselves as non-Hispanic White in Medicare, while a smaller percentage self-reported as non-Hispanic Black (10.7%), Hispanic (7.4%), Asian or Pacific Islander (8.5%), and American Indian or Alaskan Native (0.9%). These findings indicate that EMS personnel were accurately identifying the race and ethnicity of OHCA victims as per patients' self-reported information.

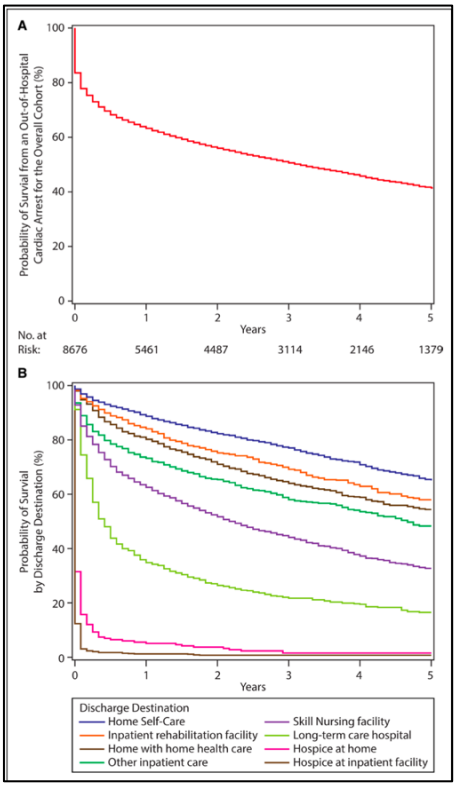

Figure 2. Long-term survival among those surviving to hospital discharge in Cardiac Arrest Registry to Enhance Survival: Mortality, Events, and Costs for Cardiac Arrest survivors from 2013 to 2019.

Figure used with permission of Wolters Kluwer Health, Inc. from Chan PS et al. Long-Term Outcomes for Out-of-Hospital Cardiac Arrest in Elderly Patients: An Analysis of Cardiac Arrest Registry to Enhance Survival Data Linked to Medicare Files. Circ Cardiovasc Qual Outcomes. 15(10):e009042 (2022). Permission conveyed through Copyright Clearance Center Inc.

Table 2. Concordance of Race/Ethnicity Data in CARES with Self-Reported Data in Medicare Files.

SELF-REPORTED RACE AND ETHNICITY IN MEDICARE DATA								
CARES Race/ Ethnicity	Total	Non-Hispanic White	Non-Hispanic Black	Hispanic	Asian/ PI	American Indian or AN	Unknown or Other	% Concordance with CARES
Non-Hispanic White	14,284	13,343	272	262	106	44	257	93.4%
Non-Hispanic Black	4771	398	4249	71	18	3	32	89.1%
Hispanic	1213	211	54	905	23	3	17	74.6%
Asian/PI	760	95	17	47	529	1	71	69.6%
American Indian/AN	90	23	18	4	4	34	7	37.8%

Abbreviations: AN, Alaskan Native; PI, Pacific Islander.

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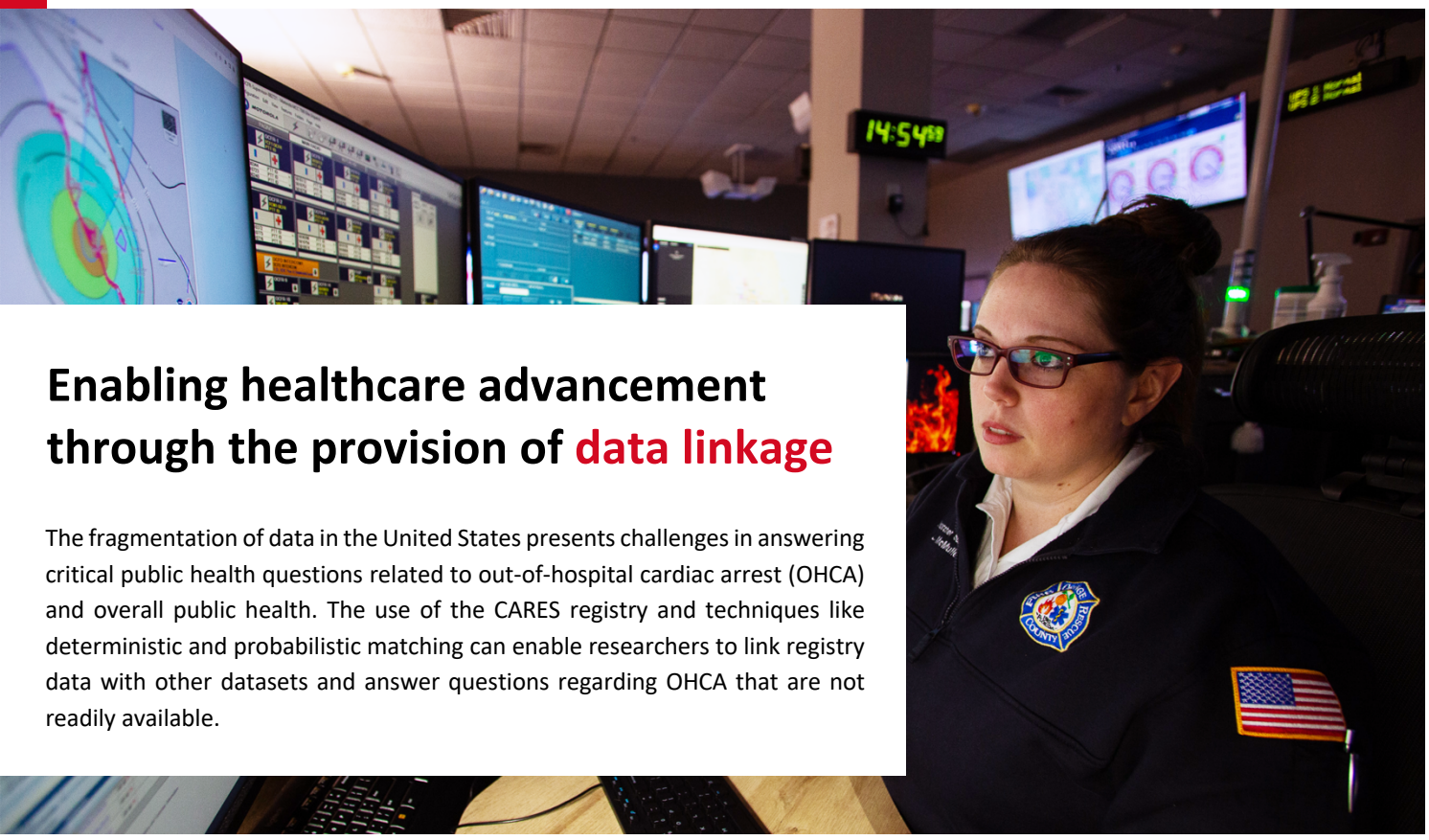
Dialysis Clinic Data Linkage

Data linkage can also be utilized to focus on a target sub-population. Out-of-hospital cardiac arrests are common in outpatient dialysis clinics, and immediate provision of CPR improves patient outcomes. However, there is a disparity in the rate at which Black patients receive CPR from dialysis clinic staff compared to White patients. By linking CARES to the Medicare Annual Dialysis Facility Report registry, researchers examined the role of dialysis facility resources and patient factors. OHCAs occurring in dialysis clinics were identified in CARES and information was extracted from the CMS's Dialysis Facility Compare online tool to obtain facility-level variables, such as characteristics, quality, and performance. Each CARES case was then linked to the corresponding dialysis facility care reports for the matching facility and year of the event. The analysis of the linked dataset revealed that Black cardiac arrest patients were dialyzed in larger facilities (26 versus 21 dialysis stations; P<0.001) with fewer registered nurses per station (0.29 versus 0.33; P<0.001), lower quality scores (6.8 versus 6.3; P=0.04), and higher proportions of patients with a history of cardiac arrest (41% versus 35%; P<0.001), HIV/hepatitis B, and Medicaid-enrolled patients compared to White patients (15% versus 11%; P<0.001). After accounting for these differences and other factors, the racial disparity in CPR provision between Black and White patients persisted, with Black patients being less likely to receive CPR (OR=0.45; 95% CI, 0.27 to 0.75). The disparity was also more pronounced among older patients than younger patients (Figure 3).



Enabling healthcare advancement through the provision of data linkage

The fragmentation of data in the United States presents challenges in answering critical public health questions related to out-of-hospital cardiac arrest (OHCA) and overall public health. The use of the CARES registry and techniques like deterministic and probabilistic matching can enable researchers to link registry data with other datasets and answer questions regarding OHCA that are not readily available.

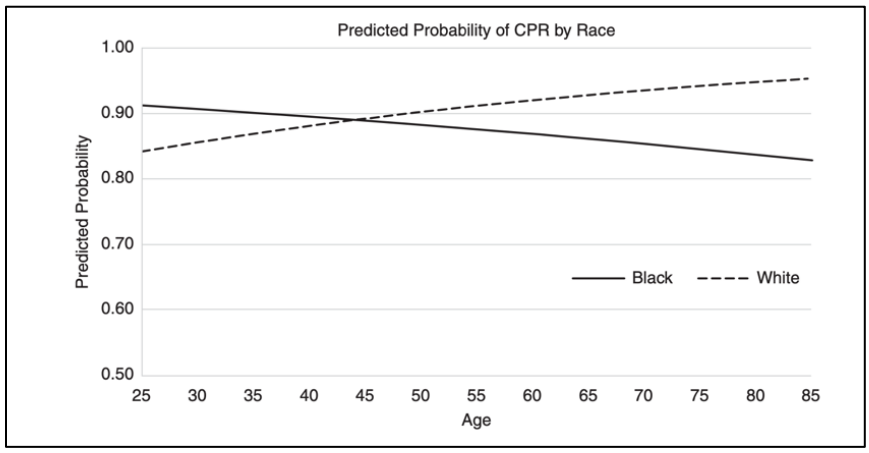


Figure 3. Predicted probability of receiving staff cardiopulmonary resuscitation according to patient race and age.

Figure used with permission of Wolters Kluwer Health, Inc. from Pun PH et al. Facility-Level Factors and Racial Disparities in Cardiopulmonary Resuscitation within US Dialysis Clinics. Kidney360. 3(6):1021-1030 (2022). Permission conveyed through Copyright Clearance Center Inc.

CPR/AED School Training Data Linkage

While there is evidence suggesting that outcomes improve with CPR and AED use, it is not clear if laws mandating CPR/AED training in schools have an impact on outcomes, or if states with such mandates differ in outcomes from those without such laws. Whether schools should require CPR/AED training is decided at the state level, and there are variations in legislative mandates across the nation. As of December 31, 2020, 39 out of 50 states and the District of Columbia mandated CPR and AED training for high school students. Associations between law status and OHCA intervention rates were therefore studied using the CARES data. All nontraumatic OHCAs from states with at least 50% population catchment during the study period were eligible for inclusion. Using the deterministic method of linkage, information on state-level CPR/AED training mandates was linked to the CARES dataset, de-identified in-house prior to analysis. More than one-half of OHCAs occurred in states with laws enacted (56.6%). Findings highlight that patients with an OHCA were more likely to receive bystander CPR (bCPR) over all age ranges (except for 13-17 years) in states with a law enacted compared to states without a law enacted. Furthermore, in states with CPR/AED training laws compared to those without laws, a greater percentage of patients who experienced OHCAs received bCPR regardless of gender, race, ethnicity (except Hispanic/other), arrest witness status (witnessed/unwitnessed), location of arrest (public/residential), or initial presenting cardiac rhythm (shockable/nonshockable). Additionally, the use of AEDs for public OHCA was also higher in states with CPR/AED training laws. These findings indicate that the association between law status and bCPR is at least partially explained by legislative mandates.

Without data linkage, healthcare initiatives fail to utilize the significant potential of rapidly growing data resources to enhance the well-being of the public. As a result, incomplete data will continue to be the basis for clinical or policy decisions. Linking different datasets together facilitates the identification of patterns and allows for validation across datasets as well as the exploration of various influences on out-of-hospital cardiac arrest survival, enabling more informed decision-making.

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2022 Publications

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

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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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