2020 Annual Report

CARES
Cardiac Arrest Registry
to Enhance Survival

A paramedic from Chesterfield Fire & EMS in Chesterfield, Virginia ventilates a patient during transport.
Photo courtesy of Chesterfield Fire & EMS.

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Note: Some photos in this report were taken prior to the COVID-19 pandemic.

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Introduction

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

However, without data on key indicators such as patient outcomes and bystander interventions, communities and EMS leadership have no information about how they are performing relative to others, as well as whether their quality improvement efforts are succeeding. Data collection is crucial in identifying gaps and planning next steps to strengthen the chain of survival. OHCA registries fill this role by compiling standardized measures at the community, state, and national level. Benefits of participating in such registries include determining patient outcomes, uniform benchmarking, identifying opportunities for improvement, and assessing the effectiveness of specific interventions[1].

The Cardiac Arrest Registry to Enhance Survival (CARES) allows communities to benchmark their performance with local, state, or national metrics to better identify opportunities to improve their OHCA care. CARES offers a comprehensive understanding of where arrests are occurring, whether bystanders are providing intervention prior to EMS arrival, EMS and hospital performance, and patient outcomes. This in turn provides the data necessary to make informed decisions and allocate limited resources for maximal community benefit. By creating an easy-to-use and flexible system to collect OHCA data and forming a community to share best practices, CARES has transformed the way EMS agencies are treating cardiac arrest. Participating agencies 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 2020, over 9,200 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 Red Cross, American Heart Association, Emory University Woodruff Health Sciences Center, and Stryker) who support our mission to save lives and improve patient care. We are pleased to present the 2020 Annual Report.

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

Providers from Durham County EMS in Durham, North Carolina survey a scene as they approach to render aid.
Photo courtesy of Durham County Office of Emergency Services.

A Year in Review

Dear CARES Community,

2020 was a year unlike any other. It's difficult to fully fathom the health impact our country has experienced since we first learned that COVID-19 arrived in the US in early 2020. It's sobering to consider how many Americans have died, been hospitalized and that continue to have lingering health effects physically, psychologically and emotionally. Vulnerable patients were impacted disproportionately but the novelty of the virus left no one immune. Medical providers worked daily often under trying conditions while offering hope to patients isolated from their families. Balancing the loss they experienced with the optimism they provided reminds us of the fragility of life and the power of human resilience.

More than 1,000 Americans daily experience a non-traumatic cardiac arrest outside the hospital. Timely and definitive care often determines whether these patients survive and return to their lives and families. This 2020 Annual Report details the three pillars of the CARES program: surveillance, quality improvement and research. It describes how resuscitation practices changed in the US during the pandemic and provides evidence, through the "CARES in Action" stories, about how to improve outcomes in the future.

Overall survival for out-of-hospital cardiac arrest (OHCA) dropped by 14% in 2020 compared with 2019 (10.5% to 9.0%), bystander AED use in public locations decreased by 26% (12.2% to 9.0%), bystander CPR by 2% (41.2% to 40.2%). These metrics and others shared in greater detail within the report emphasize the surveillance mission of the program. The quality improvement mission is described in the report with regional and state level efforts to improve OHCA care in Minnesota, Texas and North Carolina. The research mission during the early months of the pandemic found that communities with both high and low COVID mortality were impacted with decreased return of spontaneous circulation (ROSC), decreased survival, increased termination of resuscitation (TOR) rates and increased incidence of OHCA.

As we begin to emerge from this pandemic, it is important to recognize the value of surveillance data in guiding our public health decision making, including performing quality improvement activities locally to increase survival. 2020 was a year unlike any other but one that ideally prompts us to make necessary changes in our communities to be better prepared for the next cardiac arrest event.

Thank you to all of the CARES participants for their continued efforts in contributing to the registry during this year. We recognize that many of you were overextended both personally and professionally. We are truly grateful for your persistence and appreciation for how valuable this data is locally, regionally and nationally. Thank you for all that you do.

Respectfully,

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

Grady EMS "Superheroes" pose for a picture outside their ambulance after a shift.

Why CARES Matters: A Story of Survival from OHCA

The Importance of the 6th Link in the Chain of Survival: Recovery

By Kelly N Sawyer, MD, MS

June 1, 2011 – It was the first day of my last month of Emergency Cardiac Care fellowship at Virginia Commonwealth University. I was submitting my fellowship work focused on the idea of individualized targeted temperature management (TTM). It was the day I collapsed and received TTM treatment myself.

I was walking from the parking garage to the hospital for a meeting. What followed is a blur of my own memory and what others filled in for me.

Among the witnesses were two nurses, who quickly alerted the emergency department (ED). They realized the fastest way to get me treatment was to call 911 for EMS support and transport. Being indoors but at street level, navigating elevators and long hallways inside the hospital would have led to significant delays.

Dr. Sawyer's young daughter will help her celebrate 10 years of survivorship in June.

Once in the ED, my own colleagues were faced with treatment decisions that they had not expected to perform for one of their own. My vital signs were blunt, with hypotension and severe hypoxemia suggesting a cardio-pulmonary event. Bedside ultrasound of my heart revealed a large clot in the right atrium. I was taken emergently to the operating room for cardiopulmonary bypass and open-heart surgery for removal of the clot.

My ED partners debriefed, the surgical team cannulated, and my critical care team tweaked drips, temperature, and ventilator settings. They all knew, as I did, that survival from saddle pulmonary embolus complicated by shock and cardiac arrest rarely survives to admission, let alone discharge. Their decisions that day – and over the next several days – would have a direct impact on me forever.

My friends and colleagues had restless nights, waiting for my awakening. Over weeks to months, I met with many of those who had been there that day. It was important to me to fill in the gaps and reflect together on what had happened. The lasting effect of my cardiac arrest on them was clear to me. This highlights the fact that my story cannot be told without acknowledging their bravery and teamwork, as well as their worry and stress.

Like many successful survival stories, all conditions were met for an optimal chain of survival. I walked out of the hospital and later presented my research at international meetings. I was lucky to have been witnessed and treated in a health system with comprehensive systems of care. Although I had focused on optimizing TTM for comatose survivors after cardiac arrest during my fellowship, it was through my own experience that I realized how much room we had for improving long term recovery and rehabilitation for our patients, their families, and caregivers.

Sudden Cardiac Arrest Survivorship

The concept of survivorship acknowledges the holistic complexity of a critical illness. It encompasses caregivers, family, and even healthcare providers, who care for the patient and their family both outside and inside the hospital. As more people are affected by cardiac arrest and more people survive, we, as healthcare providers, have a great opportunity to impact their rehabilitation and recovery.

Recovery from a critical illness is multifaceted. Invasive procedures and prolonged immobilization in the intensive care unit often lead to physical impairments. Surviving cardiac arrest also results in cognitive, emotional, and existential challenges. Patients struggle with “Why me?”, “Why did I survive when so many do not?”, and “What now?”.

Prehospital providers may evaluate post-cardiac arrest survivors for many reasons. The root cause of a small house fire or motor vehicle accident may be cognitive dysfunction resulting from previous cardiac arrest. Survivors may struggle with attention, multitasking, or memory and thus have difficulty with everyday activities after discharge. This may not be recognized until people are home from the hospital.

Clinicians may see patients in the office or hospital who complain of long-term pain or weakness. They may be unable to return to work, intimacy, or hobbies they once enjoyed. Patients who receive defibrillators may fear being shocked and avoid activities they once enjoyed. This may have long term consequences on prevention of heart disease, stroke, and cancer.

It is increasingly recognized that long term anxiety, sadness, and even post-traumatic stress affect both patients, their family members, and rescuers. Difficulty with fear and worry may stem from doing CPR – or not performing CPR – on a loved one or watching them be resuscitated throughout the system of care.

Cardiac arrest affects our families and communities even more than our patients at times. They need resources and support as well.

Guidelines, Research Priorities, and Patient Partners

In early 2020, the American Heart Association (AHA) published a Scientific Statement on Cardiac Arrest Survivorship[2]. The statement summarizes the available literature describing the experience of patients and their families and caregivers after cardiac arrest. It also offers a roadmap to recovery that may be used to communicate across hospital systems and specialties. Finally, it identifies promising areas where further research is needed in treatment, rehabilitation, and patient-centered outcomes after sudden cardiac arrest.

2020 AHA Guidelines[3] added a 6th link to the Chain of Survival -- Recovery. This addition acknowledges the need for systematic attention to recovery, rehabilitation, and survivorship plans. Survivorship plans summarize treatments, provide follow up recommendations, and guide recovery expectations such that transitions from hospital to home may be clearer. Adding the Recovery link is the first step in aligning resuscitation treatment recommendations with those for patients surviving stroke, cancer, and other critical illnesses.

Survivors and families may be out at our CPR events or scientific meetings sharing their stories. They form peer-to-peer groups online and amplify messages from advocacy organizations. They are increasing partnerships with research groups to provide perspective and feedback. We can provide them the opportunities to add their voices as advocates for CPR training, AED use, and general cardiac arrest awareness. Their experiences will guide our research agenda as we begin to concentrate on what matters most to the survivorship community.

10 Years Later

There is still much work to be done to fill treatment gaps and ensure continuity of care after acute hospitalization. But there have been increasing research and international collaborations to address rehabilitation and recovery after cardiac arrest. Guidelines help raise the minimum bar.

Nearly 10 years later, I still have vivid memories of that day. I look back with gratitude for all those involved but acknowledge that they struggled in ways I did not. My survival story is OUR story. I recovered and I know that over time, we healed.

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[2] Sawyer KN, Camp-Rogers TR, Kotini-Shah P, Del Rios M, Gossip MR, Moitra VK, et al. Sudden Cardiac Arrest Survivorship: A Scientific Statement From the American Heart Association. *Circulation*. 141(12).

[3] Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 20:142(16_suppl_2):S366-S468.

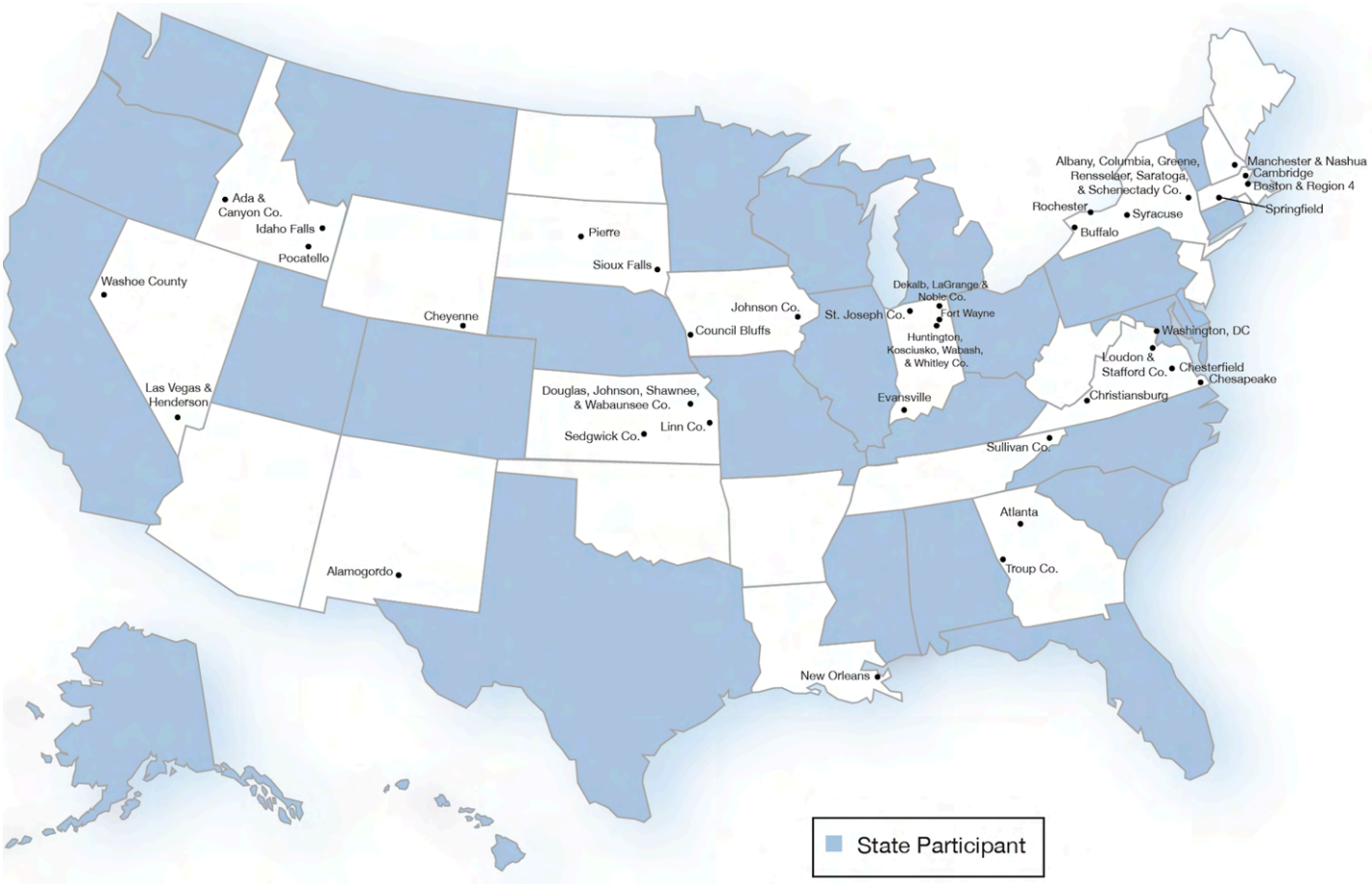
Personnel from City Miami Fire Rescue in Miami, Florida responding to a cardiac arrest patient during the COVID-19 pandemic.
Photo courtesy of City Miami Fire Rescue.

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 27 state-based registries (Alabama, Alaska, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Illinois, Kentucky, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, Texas, Utah, Vermont, Washington and Wisconsin) with more than 56 community sites in 15 additional states, representing a catchment area of approximately 162 million people or 49% of the US population. To date, the registry has captured over 600,000 records, with more than 2,000 EMS agencies and over 2,500 hospitals participating nationwide.

Figure 1. Map of 2021 CARES participants.



Case Definition

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

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

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

Data Collection & Elements

Data collection within CARES is based on the Utstein-style definitions – a standardized template of uniform reporting guidelines for clinical variables and patient outcomes that was developed by international resuscitation experts[4,5].

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, sex, and race/ethnicity), arrest circumstances (i.e. location type of arrest, witness status, and presumed etiology), and resuscitation-specific data (i.e. information regarding bystander 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.

[4] 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.

[5] 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.

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.

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/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 such that CARES staff can 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.

First responders from Horry County Fire Rescue in Conway, South Carolina load a patient into the back of an ambulance.
Photo courtesy of Horry County Fire Rescue.

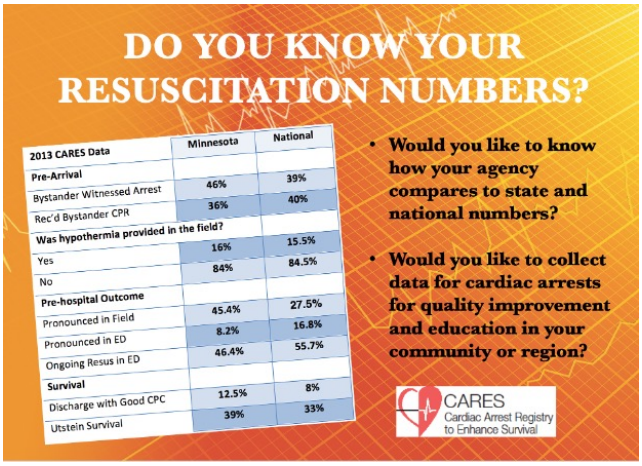
CARES in Action

Valuable Partnerships Form to Increase Survival from Out of Hospital Cardiac Arrest

By Kim Harkins, Center for Resuscitation Medicine Program Manager at University of Minnesota
Lucinda Hodgson, Minnesota CARES State Coordinator

Through the support of the University of Minnesota (UMN) and the HeartRescue Project, Minnesota began state participation in 2010, as one of the first CARES state participants in the country. To date, Minnesota-CARES captures over 85% of the state population. Minnesota's mostly rural geography and the greater Twin Cities metro area collectively boasts survival rates higher than the CARES national average and has developed a collaborative culture committed to improving survival from out-of-hospital cardiac arrest (OHCA). Much of the state's success can be attributed to widespread CARES participation and an invaluable partnership with the Helmsley Charitable Trust. The Helmsley Charitable Trust has committed more than $2.5 billion in grants with the goal of improving lives by supporting efforts in the US and around the world in health and select place-based initiatives.

Minnesota was able to achieve significant early success by promoting awareness of CARES and informing providers about the benefits of enrollment. In 2013, Minnesota launched a "Know Your Numbers" campaign and proactively shared postcards with aggregate state and national metrics to every EMS and first responding agency in the state. "This campaign was incredibly effective at not only generating interest in CARES participation, but also in acknowledging current participants' efforts and inspiring continued engagement," describes Lucinda Hodgson, Minnesota State Coordinator. "By having so much of our EMS and hospital community participating in CARES, it has created a common language where regardless of where you live in the state, we all have the same foundation to discuss data, performance and quality improvement. It is a powerful advantage in improving survival and saving lives."



Sample postcard used during the "Know Your Numbers" campaign.

In late 2018, the University of Minnesota in partnership with the health systems of the Twin Cities and greater Minneapolis-St. Paul region, approached Helmsley Charitable Trust with a proposal that redefines the future of emergency medicine. The partnership sought to create an innovative and collaborative program to provide 24/7 mobile life support services to patients suffering from OHCA. The $19.5 million grant established the Minnesota Mobile Resuscitation Consortium (MMRC), launched in the Twin Cities, with the intent of expanding across Minnesota, and serving as the guide for replication across the country. Using CARES data, the goal was to increase survival rates for OHCA patients found in a shockable rhythm from 40% to 65% in a seven-year time frame, by providing extracorporeal membrane oxygenation (ECMO) life support within 40 minutes from the initial 911 call. In order to achieve this, highly specialized critical care teams consisting of physicians, nurses and EMS personnel are deployed using "chase vehicles" to intervene in OHCA cases in local emergency departments. The next phase includes a truck (see photo on next page) that is equipped with state-of-the-art medical equipment and virtual technology to help experts attend to patients remotely, essentially bringing the emergency room to cardiac arrest patients who need to be placed on ECMO. Ultimately, location will no longer be a barrier to survival with the truck and virtual technology in full implementation.

"Having CARES allowed us to pursue such a pivotal project with Helmsley because we had baseline OHCA metrics and the ability to assess the impact of the intervention and investment in the project" explains Kim Harkins, Program Manager at the Center for Resuscitation Medicine in the University of Minnesota. To date the program has observed 63 consecutive patients, ages 18-75, enrolled in MMRC from December 1, 2019, to April 1, 2020[6]. The study observed:

- 58 patients met the criteria and were treated by the MMRC SUV response team and the mean age was 57;
- 46 of 58 patients were male;

[6] Bartos JA, Frascone RJ, Conterato M, et al. The Minnesota mobile extracorporeal cardiopulmonary resuscitation consortium for treatment of out-of-hospital refractory ventricular fibrillation: Program description, performance, and outcomes. *EClinicalMedicine*. 29-30:100632.

- 100% of patients were successfully cannulated, with no identified safety issues; and
- Of the 58 patients treated, 43% were discharged from the hospital with either a return to normal daily living or with minimal disruption to their daily life.

Minnesota Mobile Resuscitation Consortium team doing a test run with a manikin.

The MMRC mobile ECMO program relaunched in September 2020, following disruptions caused by COVID-19. Since then, the MMRC SUV response team has continued to serve cardiac arrest patients and expand the number of centers where cannulation services are provided. They are looking forward to the launch of the first truck in the late spring.

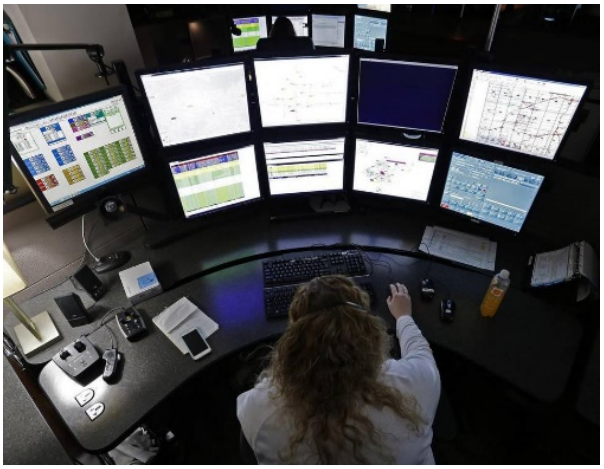
"We are so appreciative of the support of the Helmsley Charitable Trust that allows us to participate in this incredible and innovative work and we look forward to continuing to use CARES data to monitor the impact of this collaborative effort" says Dr. Demetris Yannopoulos, Director of the Center of Resuscitation Medicine and a Professor in the Medical School.

CARES Telecommunicator CPR for Hearts in Texas

By Micah Panczyk, Texas CARES State Coordinator

Telecommunicator CPR (T-CPR), or Dispatch-Assisted CPR, has been linked to improved patient outcomes across the world and is extremely cost-effective, requiring almost no capital expense. The value in lives saved cannot be overstated.

A three-stage process where telecommunicators identify potential out-of-hospital cardiac arrests (OHCA), provide pre-arrival CPR instructions, and coach callers to perform continuous CPR until professional rescuers assume care, T-CPR produces forward blood flow and can prolong ventricular fibrillation, increasing the likelihood first responders are able to shock the heart back into a normal rhythm.



9-1-1 telecommunicators can have a profound impact on patient outcomes after OHCA.

Optimal T-CPR, however, can only be achieved when 9-1-1 agencies measure the care they provide. In the words of the British mathematician Lord Kelvin, "If you cannot measure it, you cannot improve it." The CARES dispatch data collection module is a means to this end. The module allows 9-1-1 centers dispatching for CARES EMS agencies to extract key data points from OHCA audio recordings and to benchmark performance against the American Heart Association T-CPR Performance Standards. For any given event, users can track whether telecommunicators recognize OHCA and whether bystanders start chest compressions. Users can also track the time from call receipt to recognition and to first chest compression, in addition to documenting common barriers to T-CPR (e.g., a caller is not with the patient, or is unable to get the patient from a bed to the floor for CPR).

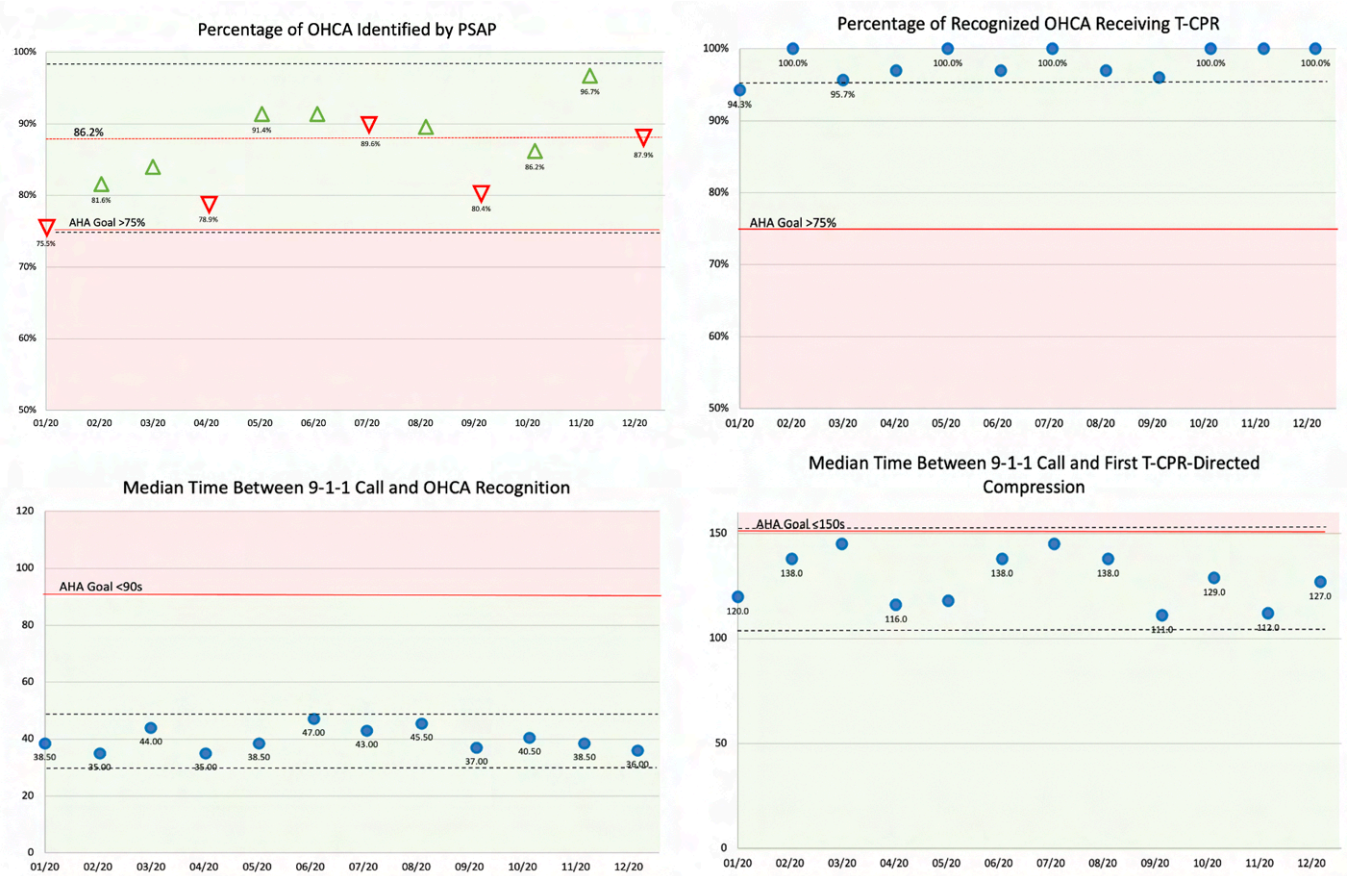
"Our service strongly believes in clinical excellence," said Dr. Veer Vithalani, Chief Medical Officer at MedStar Mobile Healthcare in Fort Worth, Texas. "We use the CARES Dispatch Module because the only way to know how you are performing is to measure and improve. The T-CPR module allows us to collect objective data on our performance for our first contact with potential cardiac arrest patients."

The module anchors MedStar's integrated T-CPR quality-improvement program. In addition to monthly and quarterly reports that document aggregate process measures, telecommunicators receive retrospective review of individual calls where care was superior or could be improved. "We get individual feedback to staff members within a week," said Lindy Curtis, the agency's T-CPR audit supervisor. "They love getting feedback that quickly – they remember the call and can really reconnect with it. It's a great learning opportunity."

Dr. Vithalani lets the staff know when they have provided care for patients who have return of spontaneous circulation (ROSC) and who survives. Survivors willing to share their experience are often introduced to EMS and telecommunicator staff.

“Oh man, we get really excited when that happens,” Lindy said. “It’s really awesome to meet someone face-to-face and to know we played a part in saving their life.”

Dr. Vithalani’s agency responded to 1,141 CARES OHCAs in 2020 and has used the dispatch module since January 2019. “We listen to all cases of OHCA to gather the T-CPR module information, and formally audit a sample of our cardiac arrests according to our Medical Priority Dispatch System guidelines,” he said. “The T-CPR quality improvement efforts have helped us set our baseline. Moving forward, it will allow us to track where things are, and whether we are 'in control' of our processes.”



T-CPR process data from MedStar Mobile Healthcare in Ft. Worth, Texas, which has been using the CARES Dispatch Module to collect and track key T-CPR metrics since January 2019.

Reviewing OHCA recordings can be time and labor intensive. Per CPR Lifelinks[7], the free federal implementation toolkit for optimizing T-CPR and EMS High-Performance CPR, it is important to note that, if a 9-1-1 center isn’t able to review all cardiac arrest recordings as recommended, it should create a sustainable plan for reviewing as many as possible.

“When used for reporting and feedback with individual telecommunicators, these reviews are an indispensable quality-improvement tool”, said Dr. Ben Bobrow, Principal Investigator for CPR LifeLinks and Chair of Emergency Medicine at McGovern Medical School in the University of Texas Medical Center at Houston. “Measurement alone improves the care we provide and allows us to identify successful practices through benchmarking over time.”

[7] https://www.ems.gov/projects/cpr-lifelinks.html

RACE-CARS Grant Using CARES Registry Awarded by NIH

By Chris Granger, MD, Principal Investigator, Director, Cardiac Care Unit, Duke University Medical Center

North Carolina, as one of the longest standing state participants, has over a decade of CARES data from across the state. In 2020, Duke University was awarded a 7-year grant, called "RACE-CARS" (Regional Approaches to Cardiovascular Emergencies – Cardiac ARreSt (RACE-CARS). RACE-CARS is a National Heart Lung & Blood Institute (NHLBI)-sponsored cluster-randomized trial to test the implementation of community interventions to improve survival for people with cardiac arrest in North Carolina.

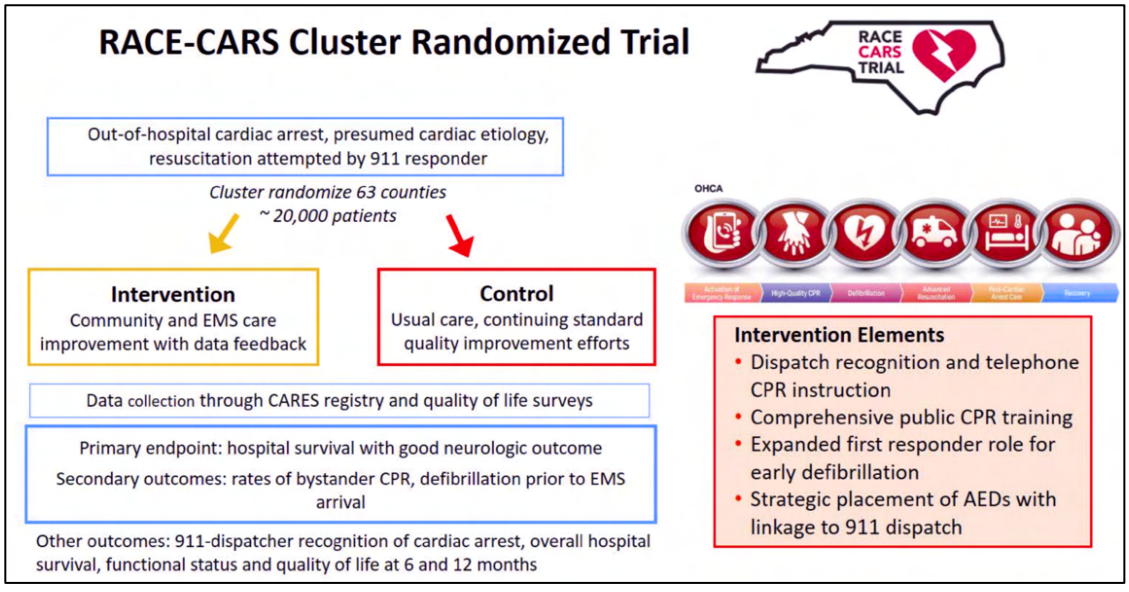
"In addition to addressing a major public health issue, the trial is innovative in being imbedded in the CARES Registry" describes Dr. Monique Starks, a member of the trial team. RACE-CARS is the first entirely "registry-based" trial in the United States, an approach that has been used to great advantage in conducting efficient clinical trials in Europe.

CARES will be used to perform patient enrollment (with waiver of individual informed consent) and to collect all baseline characteristics and primary outcome data. This accomplishes two elusive goals in randomized trials: it makes the trial highly efficient, and it makes the trial highly representative and relevant since the entire eligible population is automatically enrolled.

The premise for RACE-CARS is based on prior observations utilizing CARES data, showing substantial regional heterogeneity in care correlated with variations in outcomes. RACE-CARS will examine the effectiveness of a multifaceted intervention compared to usual care. The structured intervention program will consist of four major elements:

- comprehensive community training of lay people in CPR and defibrillator use
- optimized 911 EMS dispatch performance including recognition of possible cardiac arrest
- enhanced bystander initiation of CPR with 911 operator coaching
- improved first responder performance to achieve earlier use of defibrillators.

If successful, these interventions would provide a roadmap for communities throughout the U.S. to improve patient outcomes from OHCA and save lives.



Sixty-three counties across North Carolina have been randomized to intervention versus control. RACE-CARS will engage EMS agencies, community health centers, and local community groups. The primary objective of the RACE-CARS trial is to improve survival to hospital discharge with good neurologic function by one third, increasing the rate from approximately 9% currently to 12%. In addition, quality of life and neurological functional status will be assessed at 6 and 12 months.

The trial team includes Clark Tyson and Lisa Monk, as well as Drs. Jollis, Granger, Starks, Al-Khalidi, and Mark at Duke University. "We are excited to have the opportunity to do a major NHLBI trial with CARES as the data system," says Dr. Jamie Jollis. "Our hope is that this is only the beginning of future studies leveraging an existing data system like CARES, to advance research and quality improvement for OHCA."

CARES Communities Respond to COVID-19

The effect of the COVID-19 pandemic on resuscitation practices is evident in the national 2020 CARES dataset and is summarized on page 40 of this report. Understanding the impact of COVID-19 at the local level is important in helping communities develop strategies to improve OHCA care as we reemerge from the pandemic.

Three CARES communities - Ventura County EMS in California; Chicago Fire Department in Illinois; and Wake County EMS in North Carolina - provide insight from the field about adapting their resuscitation practices due to COVID-19.

Ventura County EMS, California

By Daniel Shepherd, MD, Medical Director, Ventura County EMS

In 2008, the Ventura County Emergency Medical Services Agency began implementing a novel approach to cardiac arrest resuscitation. "Cardiac Arrest Management," or CAM, uses a "pit-crew" style approach and emphasizes performance-focused training, high-quality CPR, and early defibrillation. CAM improved survival, particularly in the Utstein subset. The percentage of survivors with a good or moderate CPC score doubled. Subsequent updates incorporated CPR instructions by emergency medical dispatchers, new ventilation techniques, and a post-resuscitation care bundle.

In early 2020, the next evolution of CAM was being designed when the pandemic hit. Cardiac arrest survival soon declined and has yet to rebound. COVID-19 was the suspected cause, but everything was reviewed from recent protocol updates to ambulance deployments. The CARES data was shared with the dispatch agency, prehospital providers, Medical Examiner, and hospitals as leaders searched for a correctable cause.

It was found that the number of arrests, specifically unwitnessed arrests, increased while the rate of bystander CPR and AED use decreased. Additionally, and potentially most importantly, the time from dispatch to initial defibrillation increased. Prehospital providers have always worn personal protective equipment (PPE) but caring for patients in the COVID-19 era requires additional PPE and other precautions. Prior to 2020, 42.7% of patients were defibrillated in under 8 minutes, 66.7% in under 10. In 2020, these rates were 30.8% and 58.2% respectively. The etiologies of arrest remained consistent, with the exception of overdose deaths, which increased by 69% in 2020.

The stark reality of living during a pandemic is that the chances of surviving a cardiac arrest are lower than they otherwise would be. Care for chronic conditions is being deferred, people are afraid to go to the hospital, and some are reluctant to activate 911. EMS systems across the country are finding that cardiac arrest survival has declined during the pandemic. Ventura County is just beginning to emerge from a sizable surge of COVID-19.

What remains to be seen is if survival from cardiac arrest will increase as the prevalence of coronavirus decreases.

Chicago Fire Department, Illinois

By Joe Weber, MD, FAEMS, Medical Director, Chicago West EMS System

While the City of Chicago avoided the terrible crises from COVID-19 seen on the east and west coasts, the pandemic still had a significant impact on the city and the EMS System. The first coronavirus case was recorded in early March 2020 and was followed by a significant first wave that peaked at the end of April, with new case counts above 1,400 patients per day.

Early in the pandemic, with a stay-at-home order in effect, the overall EMS transport volume for the Chicago Fire Department decreased by 13%. At the same time, however, the out-of-hospital cardiac arrest (OHCA) call volume greatly increased with cases in April, May and June averaging 53% above the historical baseline. The Chicago Fire Department has prioritized high quality OHCA care for many years and the significant increase in patient volume combined with the inherent obstacles of caring for patients during an infectious disease pandemic put significant strains on EMT's and paramedics. Chicago Fire Department and EMS system leaders partnered to reprioritize the approach to OHCA with a focus on EMS provider safety while maintaining the highest quality OHCA care.

Specific initiatives included proper utilization of PPE during resuscitation, minimization of crew exposure, and utilization of advanced airways with viral filters. There was a continued emphasis for on scene resuscitation and field termination of resuscitation with a goal of transporting patients with return of spontaneous circulation and a de-emphasis on epinephrine use after three doses.

The men and women of the Chicago Fire Department, like EMS agencies all across the country, quickly embraced the new challenges presented by COVID-19 and, in time CARES data will reveal how resuscitation practice is impacted in the long term.

Wake County EMS, North Carolina

By José G Cabañas, MD, MPH, FAEMS, Medical Director, Wake County EMS

The Wake County EMS System reported 828 CARES arrests in 2020, compared with 701 in 2019. While the overall number of OHCAs increased, so did the percentage of arrests that occurred at home (73.7% in 2020 vs 67.4% in 2019) and the percentage of bystander witnessed arrests (43.4% in 2020 vs 41.3% in 2019). This is intuitive given the broad and long-lasting stay-at-home restrictions in our county and state. Conveniently, and possibly for the same reason, our rate of bystander CPR (36.6% in 2020 vs 33.6% in 2019) increased as well.

From a professional response standpoint, there was concern that the additional COVID-19 PPE requirements would delay critical interventions, but aside from mandating a higher level of PPE, we did not change our standard response plans or cardiac arrest care protocols and procedures. Fortunately, our overall survival rate increased from 12% in 2019 to 14% in 2020, and our Utstein Bystander survival rate increased from 40.4% in 2019 to 46.8% in 2020.

We believe that our CARES data from 2020 compared with 2019 highlights that the pandemic affected geographically separate EMS jurisdictions differently. EMS system medical directors must understand the current community disease burden prior to making changes in clinical care for time and intervention-dependent conditions. Before making significant changes to cardiac arrest care, ensuring EMS clinicians utilize a coordinated approach that allows donning necessary PPE while providing early time-critical interventions is valuable.

Paramedics from Wake County EMS in Wake County, North Carolina safely transfer an OHCA patient to a nearby ambulance during the COVID-19 pandemic.

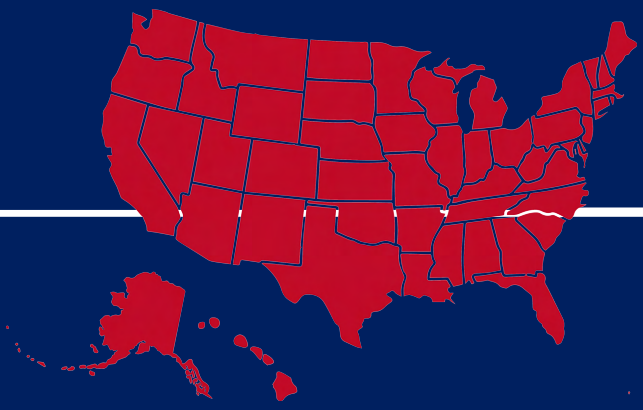
Summary

These three EMS agencies provide local perspectives on how COVID-19 impacted both urban and suburban communities while suggesting how population density, bystander interventions and the timeliness of care may have impacted OHCA survival during the pandemic.

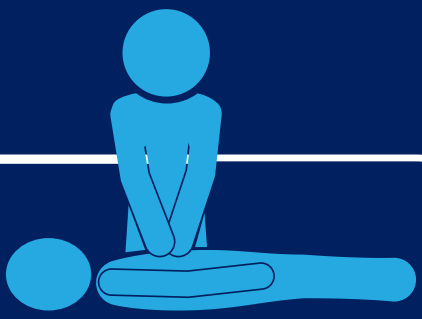
Research utilizing national CARES data during the early months of COVID-19 highlighted the impact on resuscitation practice including decreased return of spontaneous circulation (ROSC) and survival, and a significant increase in termination of resuscitation (TOR) and overall incidence of OHCA[8]. Interestingly, communities with both low and high COVID-19 mortality were impacted during the initial pandemic period, although to varying degrees.

The hope is that lessons learned in 2020 will translate into improved OHCA outcomes in 2021 and beyond.

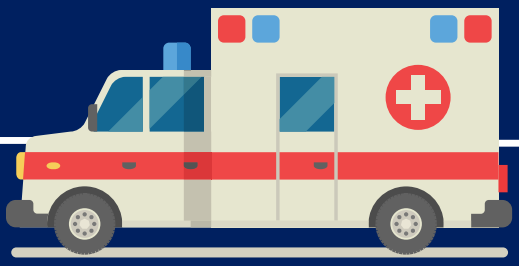
[8] Chan P, Girotra S, Tang Y, Al-Araji R, Nallamothu B, McNally B. Outcomes for Out-of-Hospital Cardiac Arrest in the United States During the Coronavirus Disease 2019 Pandemic. *JAMA Cardiol*. 6(3):296-303.



127,376 non-traumatic, worked OHCAs reported to CARES in 2020



40.2% of patients received bystander CPR



Median EMS response time: 7.3 minutes
27.1% of patients achieved sustained ROSC in the field

9.0% of patients who arrested in public had a bystander applied AED

24.0% of patients survived to hospital admission

45.4% of admitted patients received hypothermia care

9.0% of patients survived to hospital discharge

79.4% of discharged patients had a positive neurological outcome (CPC 1 or 2)

Incidence & Demographics

2020 Dataset and Incidence of OHCA Events

This report describes CARES data from the most recent calendar year, January 1 to December 31, 2020. 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 2020 National Reports can be viewed at: https://mycares.net/sitepages/reports2020.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 2020 dataset includes 1,741 EMS Agencies and 1,962 Hospitals, and represents a population of 143.5 million, approximately 44% of the U.S. population. In 2020, 127,376 OHCA events were reported to CARES. The crude incidence of non-traumatic, worked arrests was 88.8 per 100,000, significantly greater than the incidence rates observed for the three preceding years (range: 74.3-76.5 per 100,000). Using 2020 census data to extrapolate to the U.S. population[9], CARES estimates that there were approximately 291,500 EMS-treated, non-traumatic OHCAs in the United States last year.

Demographics

In 2020, CARES patients were predominately male (62.1%). Of the reported OHCA events, 97.6% (n=124,262) were adults and 2.4% (n=3,073) were children, 18 years and younger. The median age of OHCA patients was 65.0 years (mean: 62.3; SD: 19.0). The age distribution varied significantly across the sexes (Figure 2), with females having a higher median age of arrest (66.0 vs 64.0 years, p<.0001).

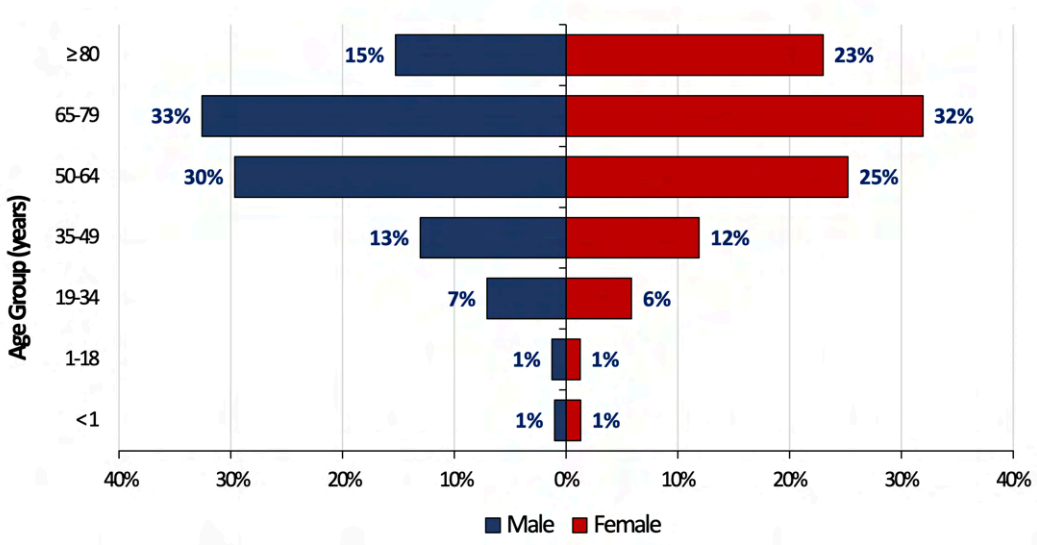


Figure 2. Age distribution of OHCA events.

[9] Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2019 Source: U.S. Census Bureau, Population Division.

Etiology

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

In 2020, 81.6% of adult (>18 years of age) OHCAs were presumed to be of a cardiac cause. Other causes of adult OHCA were: respiratory/asphyxia (9.3%), drug overdose (6.4%), exsanguination/hemorrhage (0.8%), drowning/submersion (0.4%), and other medical (1.5%) (Figure 3).

The etiology of arrest for pediatric patients (≤18 years of age) differed substantially from that of adults. In 2020, 39.9% of pediatric arrests were presumed to be of a cardiac etiology. Other causes of pediatric OHCA were: respiratory/asphyxia (37.1%), drowning/submersion (8.1%), drug overdose (6.4%), SIDS/SUID (5.2%), and other medical (3.3%) (Figure 4).

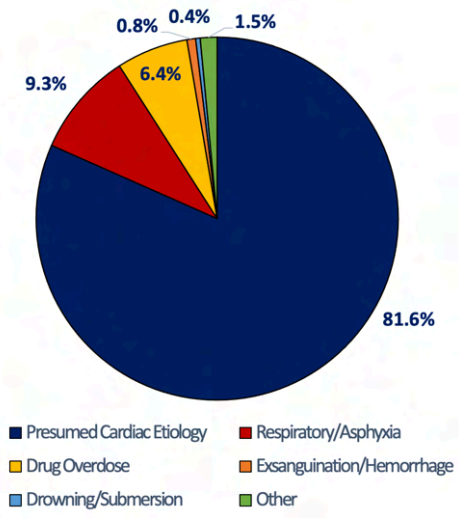


Figure 3. Etiology of arrest for adults.

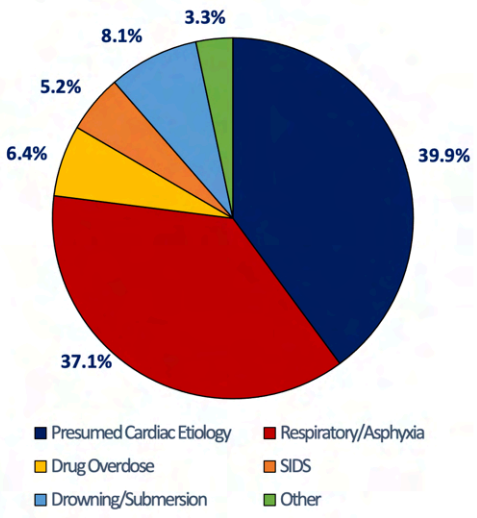


Figure 4. Etiology of arrest for pediatric patients.

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 39% of arrests in the 19-34 age group and 17% of arrests in the 35-49 age group, highlighting the impact of the current opioid epidemic in the United States.

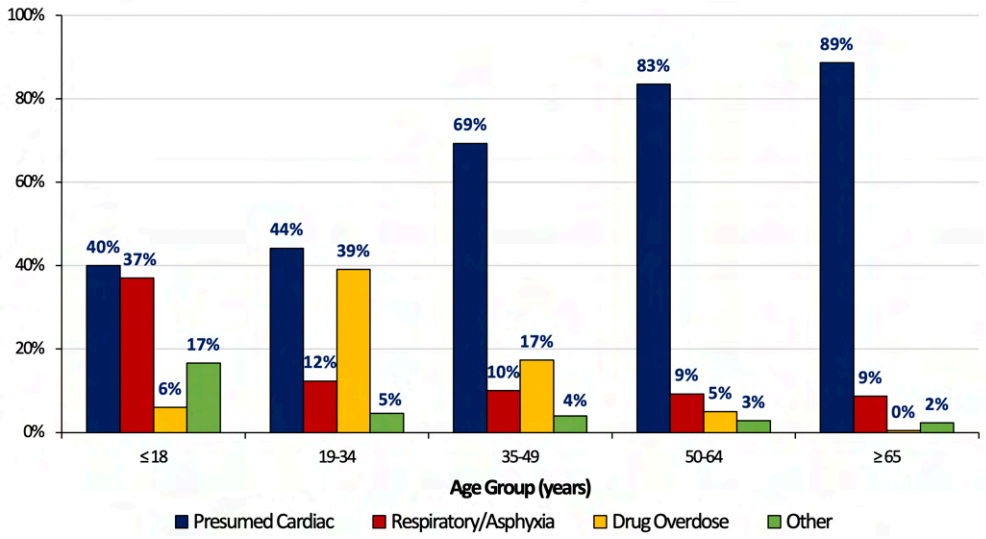


Figure 5. Etiology of arrest by age group.

Location of Arrest

The most common place for an OHCA to occur is in a residential setting, with 74.2% of events occurring in a home. Other common arrest locations were nursing home (10.7%), public or commercial building (5.7%), street or highway (4.3%), and healthcare facility (3.4%) (Figure 6).

The location of an OHCA is highly correlated with bystander intervention and patient outcome. In comparison to residential arrests, patients who arrested in a public setting were far more likely to have a bystander witnessed event and receive bystander CPR prior to EMS arrival (Figure 7). Patient outcomes were also significantly different across incident locations, with public arrests having a 2.6-fold rate of survival to hospital discharge compared to residential arrests (20.1% vs 7.8%, respectively; p< .0001).

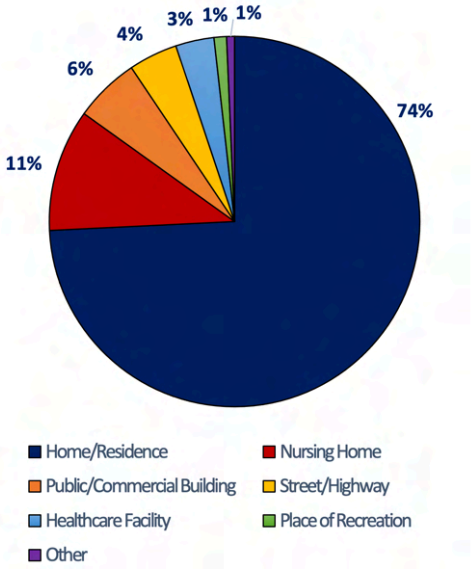


Figure 6. Location of arrest.

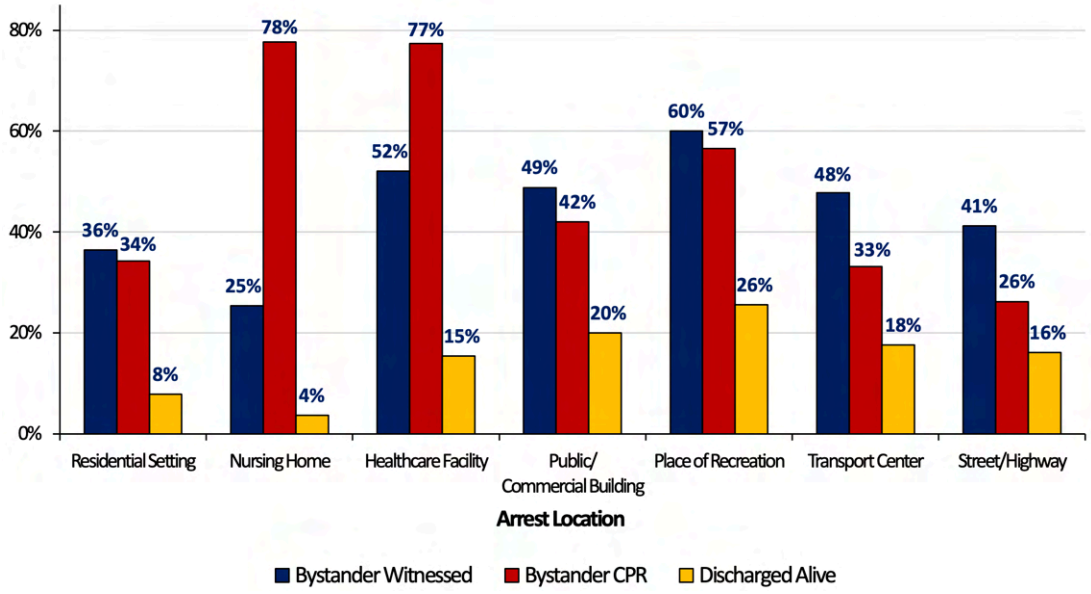


Figure 7. Percentage of events that are bystander witnessed, receive bystander CPR, and survive to hospital discharge by arrest location.

Witness Status

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

Approximately half of arrests were unwitnessed (50.1%), while 37.1% were bystander witnessed and 12.8% were witnessed by a 911 Responder (Figure 8). Patients with a bystander witnessed arrest were more than 3 times as likely to survive their event compared with unwitnessed arrests (13.4% 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 (15.3% vs 4.1%, respectively; p<.0001).

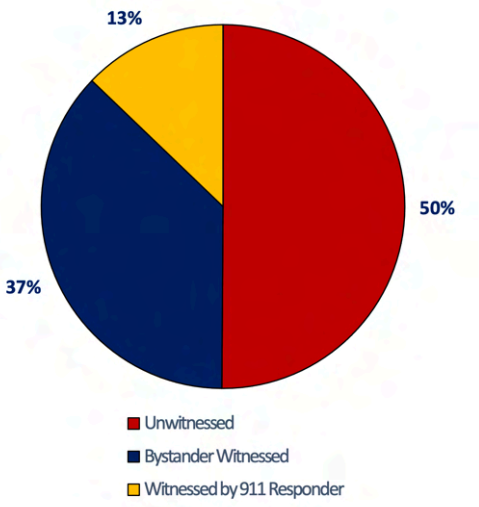


Figure 8. Arrest witness status.

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 (25.8% vs 5.6%, p<.0001).

16.5% of patients presented with an initial shockable rhythm of ventricular fibrillation (VF) or ventricular tachycardia (VT), while 83.5% of patients presented in an unshockable rhythm, with asystole being the most common (53.2%). Presenting rhythm differed markedly by arrest witness status, with bystander witnessed patients being much more likely to present in a shockable rhythm than unwitnessed patients (25.9% vs 9.6%, respectively; p<.0001) (Figure 9).

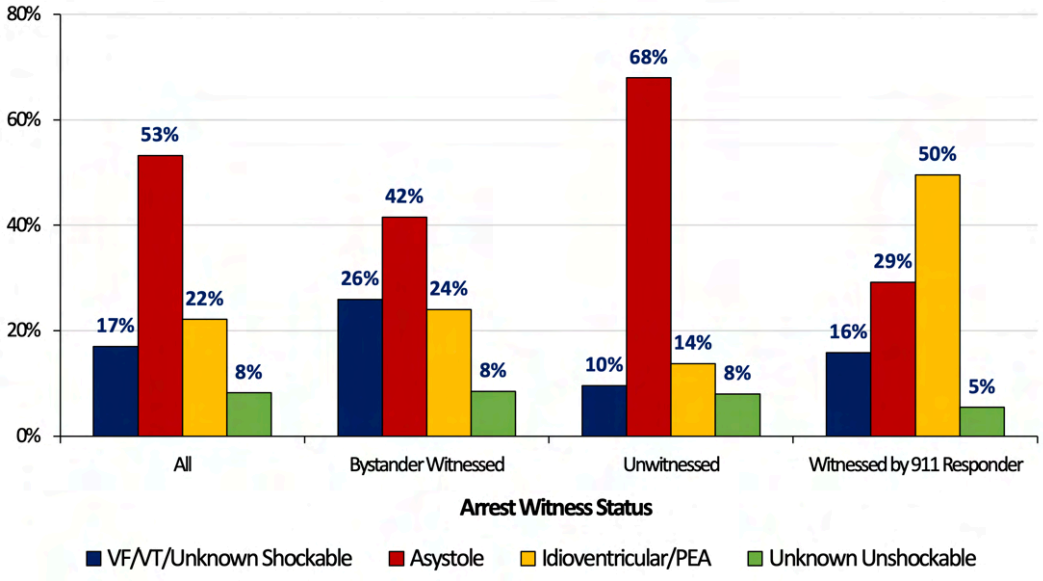


Figure 9. Presenting arrest rhythm by arrest witness status.

Activation of emergency response system

Early CPR

Early defibrillation

Rapid delivery of EMS care

Chain of Survival

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

Activation of the emergency response system

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

Response and treatment times are supplemental elements in CARES; however, participants are encouraged to measure response times in order to identify local opportunities for improvement. Records with missing response times (18.5%) as well as those that were witnessed by a 911 Responder (12.8%), have been excluded from response time analyses.

In 2020, median response time by First Responders was 6.3 minutes (IQR: 5.0 - 8.4 minutes) and median response time by EMS was 7.3 minutes (IQR: 5.3 - 10.0 minutes). First Responders arrived on scene in ≤ 5 minutes for 27.5% of arrests, while EMS arrived on scene in ≤ 9 minutes for 67.1% of arrests.

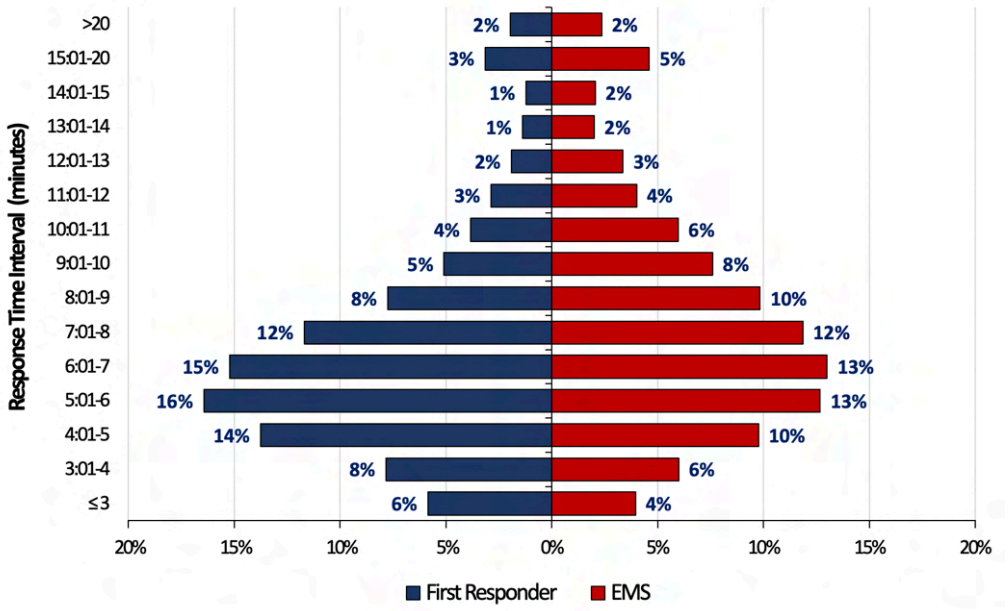


Figure 10. Distribution of First Responder and EMS response times (time interval from 911 call to arrival on scene).

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

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

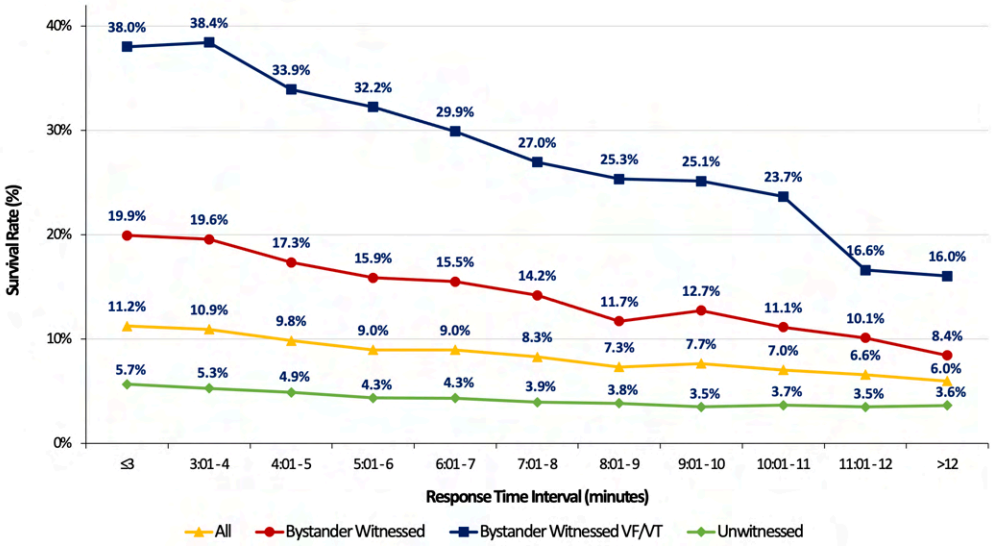


Figure 11. Survival rate by EMS response time and arrest witness status.

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

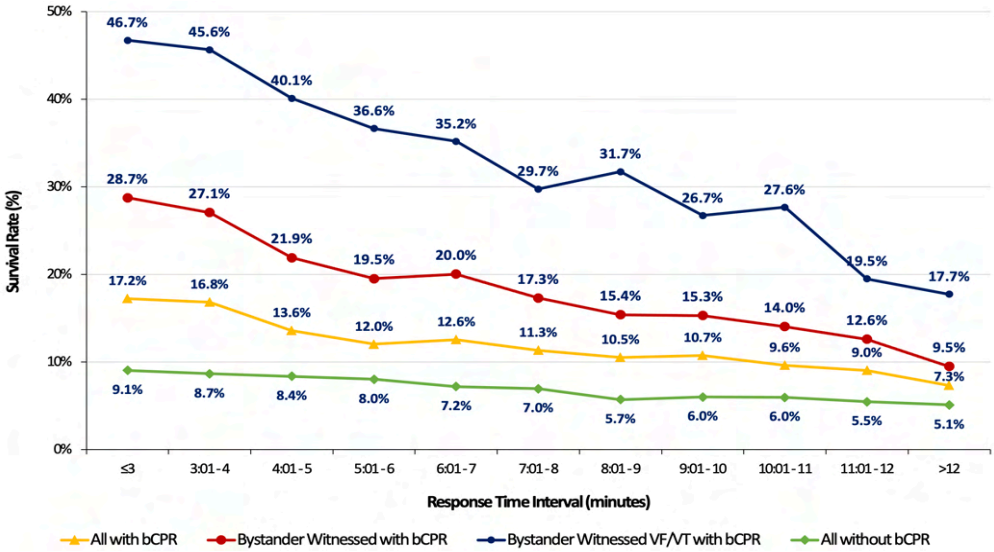


Figure 12. Survival rate by EMS response time and arrest witness status, among patients who received bystander CPR.

A 911 dispatcher from Plano, Texas ready to respond to calls from people in need and rapidly dispatch police, fire, and EMS to help.
Photo courtesy of Plano Fire Dispatch Center.

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 2020, bystander CPR was initiated on 40.2% of CARES patients. Of note, CARES excludes 911 Responder witnessed events as well as those that occurred in a nursing home or healthcare facility from our bystander CPR rate, as these are scenarios where we would expect CPR to be performed by a trained medical provider.

Bystander CPR provision was strongly correlated with arrest witness status (Figure 13). Bystander CPR was initiated after 48.0% of bystander witnessed events, compared with 34.1% of unwitnessed events (p<.0001).

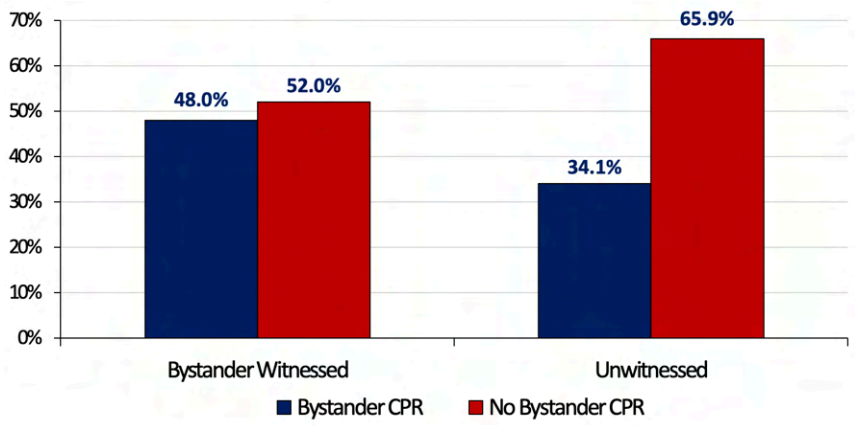


Figure 13. Bystander CPR provision by arrest witness status.

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 (11.1%) was significantly (p<.0001) higher than that of patients who did not receive bystander CPR (6.6%).

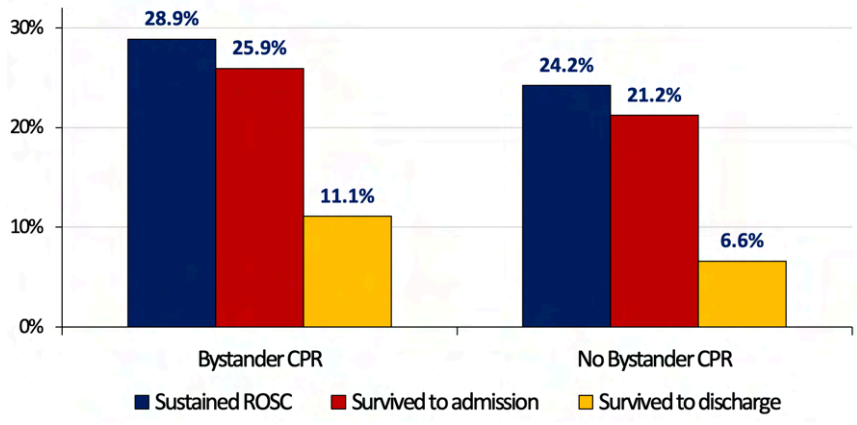


Figure 14. Unadjusted survival outcomes after bystander CPR.

Early Defibrillation

More than 15% of OHCAs occur in a public location; therefore, public access AEDs and community training have a large role to play in early defibrillation. However, the number of patients who have an AED applied by a bystander remains low, occurring after only 9.0% of public arrests.

In 2020, 28.4% (n=36,143) of CARES patients were defibrillated in the field. The proportion of patients first defibrillated by a bystander was 4.4%, whereas 18.3% and 77.3% were first defibrillated by a first responder or EMS personnel, respectively.

Reducing delays to defibrillation leads to better outcomes for patients in a shockable rhythm. Unadjusted outcomes for this subset of patients vary according to who performed the first defibrillation (Figure 15). The proportion of OHCA patients surviving to hospital discharge when first defibrillated by a bystander with an AED was 38%, compared with 24% of patients first shocked by a first responder and 25% of patients first shocked by responding EMS personnel.

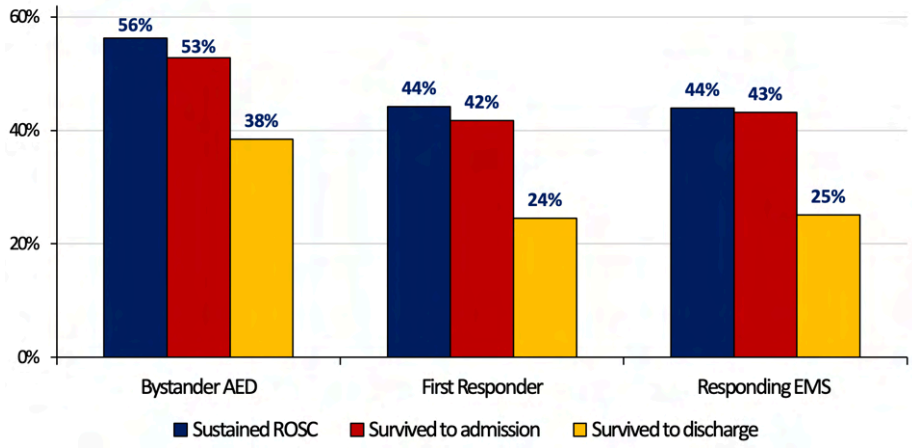


Figure 15. Unadjusted survival outcomes by who performed first defibrillation in the population with a shockable presenting rhythm.

Survival Outcomes

Patient Outcomes

On the basis of local EMS agency protocols, 42.4% of patients were pronounced on scene after resuscitative efforts were terminated in the pre-hospital setting (Figure 16). A successful attempt at resuscitation in the field is often defined by a patient's return of spontaneous circulation (ROSC). In 2020, sustained ROSC (20 consecutive minutes of ROSC, or present at transfer of care to a receiving hospital) was achieved by 27.1% of CARES patients.

The rate of survival to hospital admission was 24.0% (ED outcome missing for 181 cases; 0.1%), and the rate of survival to hospital discharge was 9.0% (hospital outcome missing for 196 cases; 0.15%). 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).

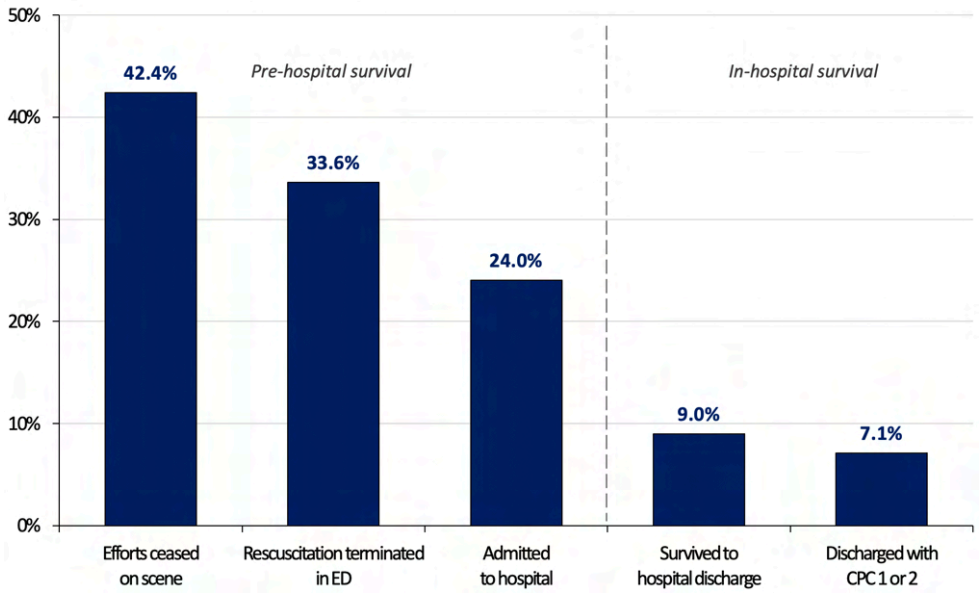


Figure 16. Unadjusted pre-hospital and in-hospital OHCA patient outcomes.

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 8.0%. Survival among patients with an arrest caused by a respiratory mechanism or drowning was slightly higher (11.3 and 11.6%, respectively), whereas patients with an overdose-related arrest had a survival rate of 18.4%. Survival was lowest among patients with an arrest due to exsanguination or hemorrhage (3.6%) (Figure 17).

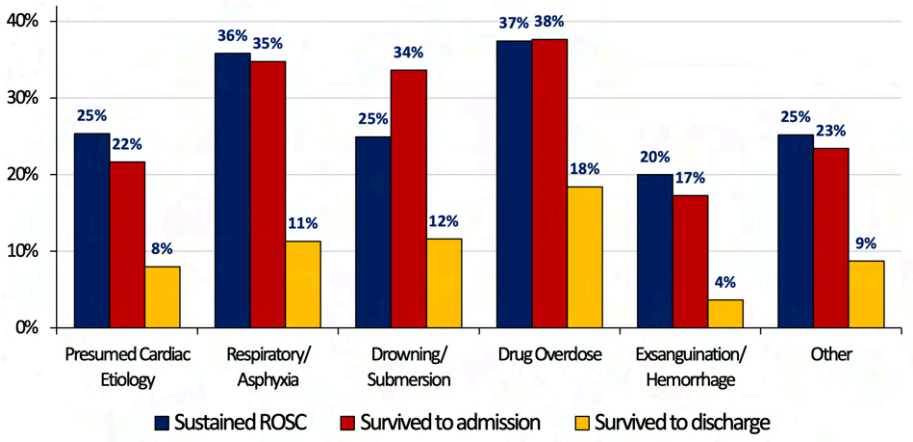


Figure 17. Unadjusted survival outcomes by arrest etiology.

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 43.5%, compared with 30.6% for those in PEA and 14.1% for those in asystole. Similarly, patients presenting in a shockable rhythm had a greater chance of being discharged alive (25.8%), compared with 9.7% of patients presenting in PEA and 2.1% of patients in asystole.

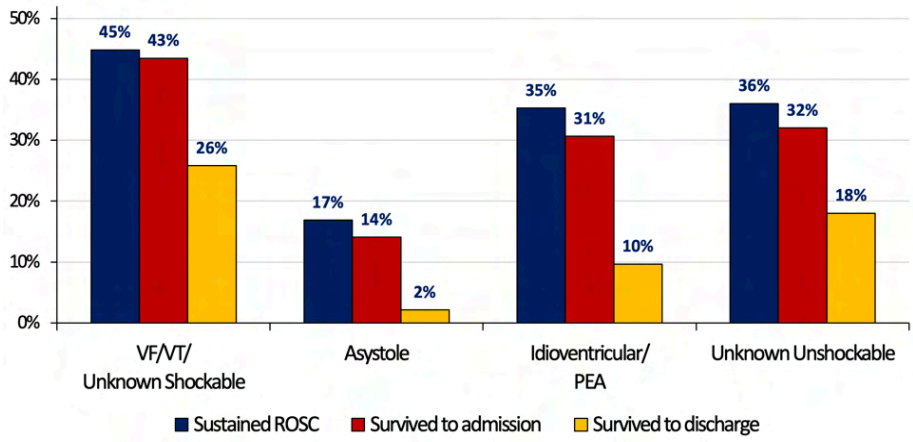


Figure 18. Unadjusted survival outcomes by presenting arrest rhythm.

Arrest witness status also has a significant impact on patient outcomes, as witnessed arrests have more opportunity for bystander intervention and early delivery of care. OHCA patients with a 911 Responder witnessed arrest had the highest chance of survival to hospital discharge (15.3%), followed closely by those with a bystander witnessed arrest (13.4%). In contrast, unwitnessed events had a survival rate of 4.1% (Figure 19).

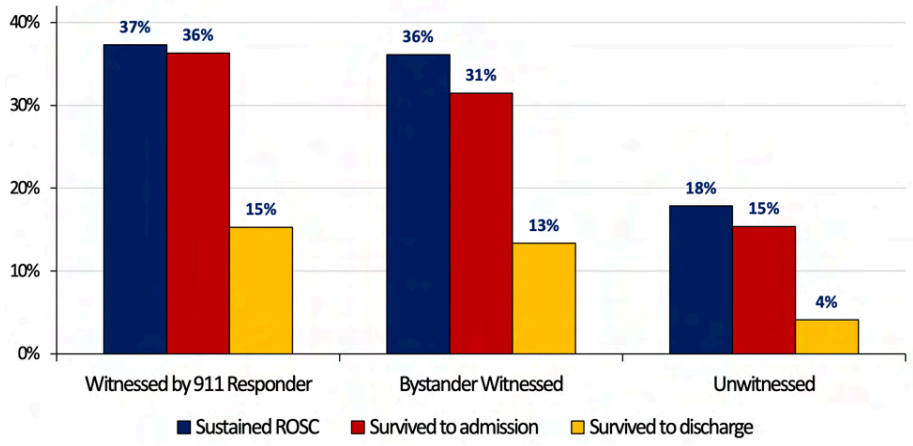


Figure 19. Unadjusted survival outcomes by arrest witness status.

Utstein Survival

The Utstein template was developed by international resuscitation experts to promote uniform reporting guidelines for clinical variables and patient outcomes[2,3]. 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 2020. This report stratifies arrests by witness status and presenting rhythm. In 2020, the survival to hospital discharge rate for the Utstein subgroup was 29.2%. 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 33.0%.

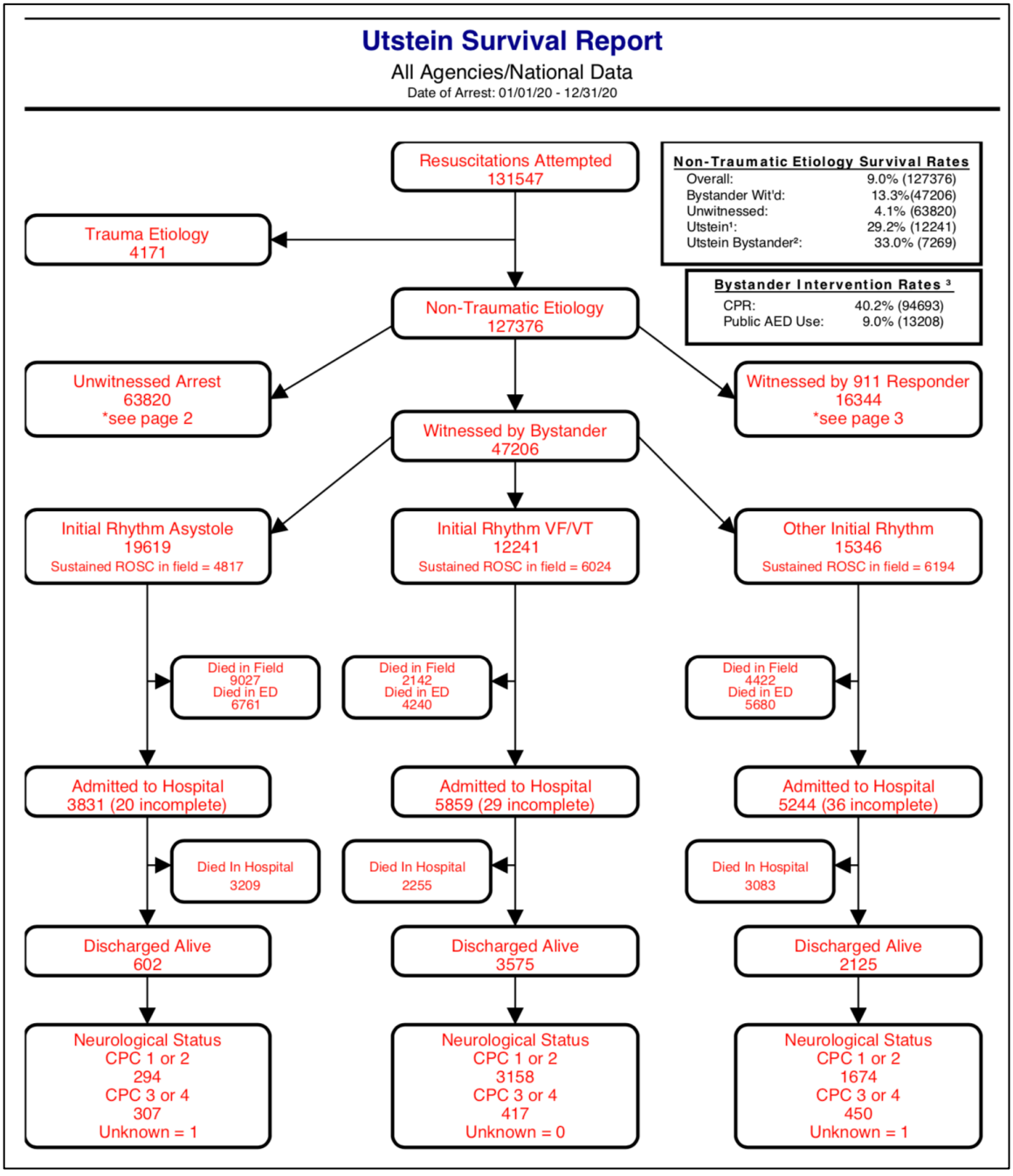


Figure 20. 2020 CARES Non-Traumatic Etiology Utstein Survival Report.

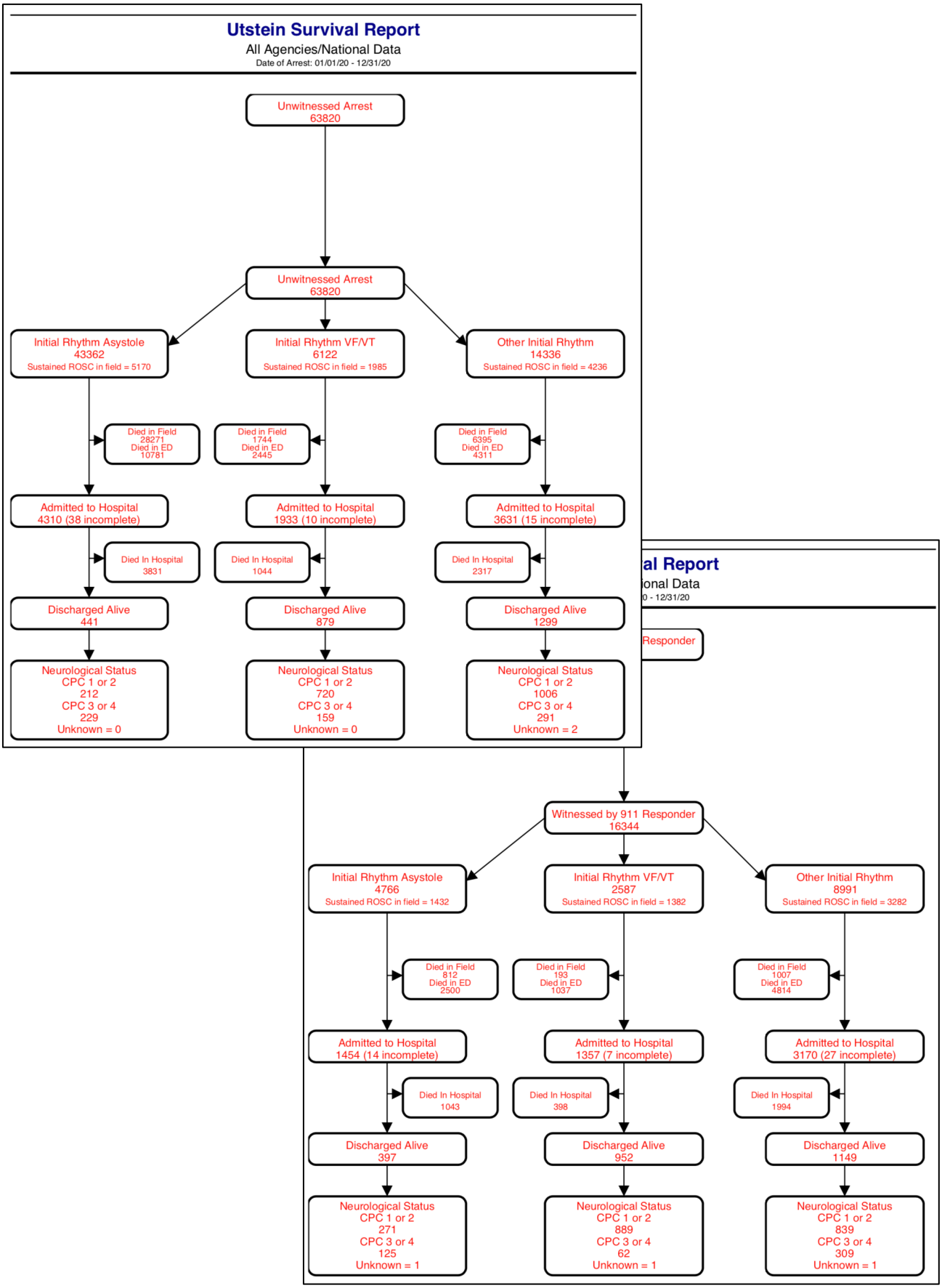


Figure 20. 2019 CARES Non-Traumatic Etiology Utstein Survival Report.

Physicians and the medical team at Northwest Texas Healthcare System in Amarillo, Texas provide quality, compassionate emergency care.
Photo courtesy of Northwest Texas Healthcare System.

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 2020.

Among all patients transported to a hospital, the survival to admission rate was 41.7% and the survival to discharge rate was 15.6%. Survival to hospital discharge was substantially higher among those who achieved sustained ROSC in the field (30.8%) compared with those who did not (2.3%), and among those who were transferred from another facility (43.2%) compared with patients who were transported directly by EMS (14.2%).

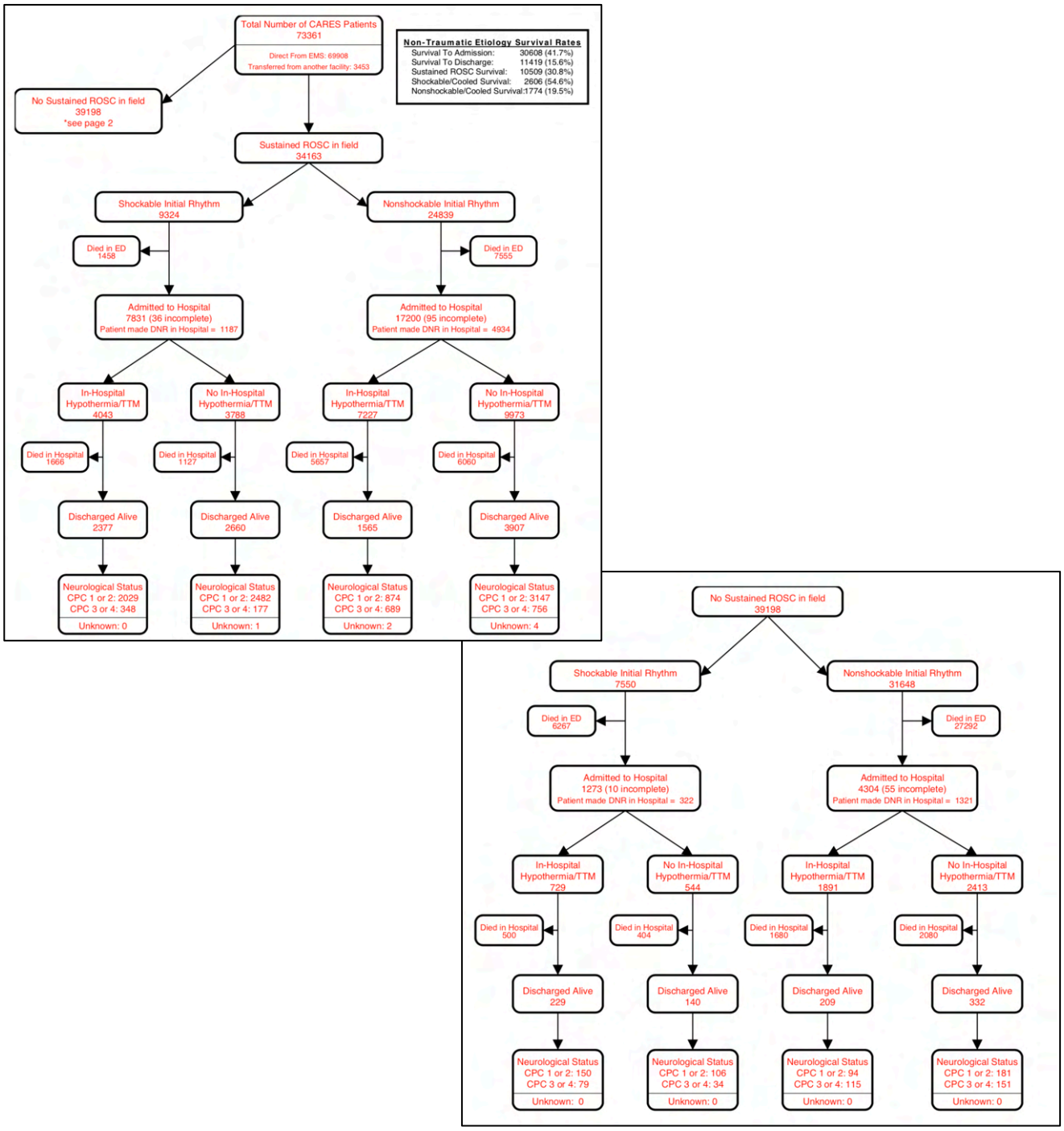


Figure 21. 2020 CARES Non-Traumatic Etiology Hospital Survival Report.

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 156 EMS agencies with ≥200 CARES cases in 2020. These figures highlight the significant variability among participating agencies (ranges: overall survival 1.3–24.4% (more than 18-fold difference); Utstein survival 0.0–55.6%; bystander CPR 7.0–75.5% (more than 10-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: 9.0%; Utstein survival: 29.2%; bystander CPR: 40.2%), while the grey vertical lines indicate quartile cutpoints.

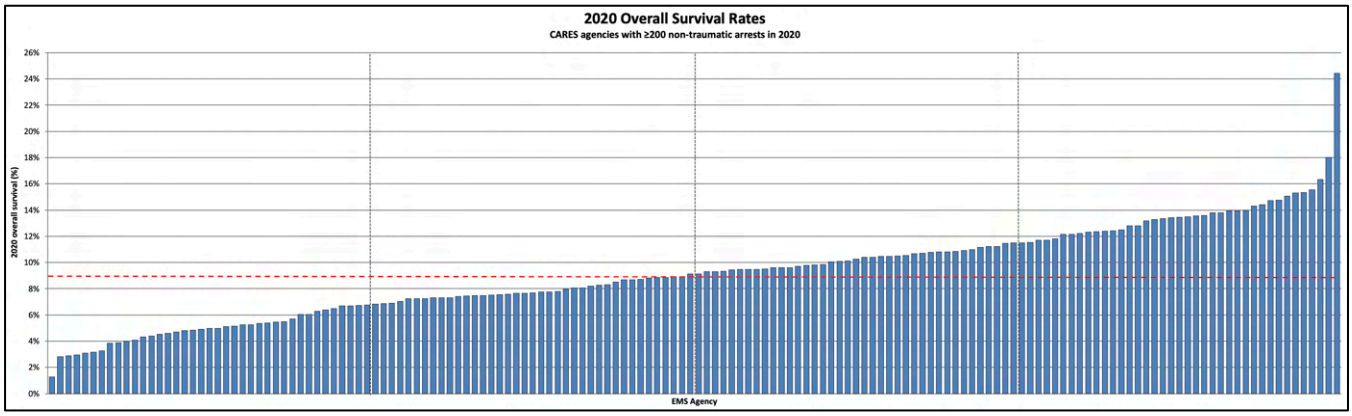


Figure 22. Variability in overall survival rates, among EMS agencies with ≥200 CARES cases in 2020.

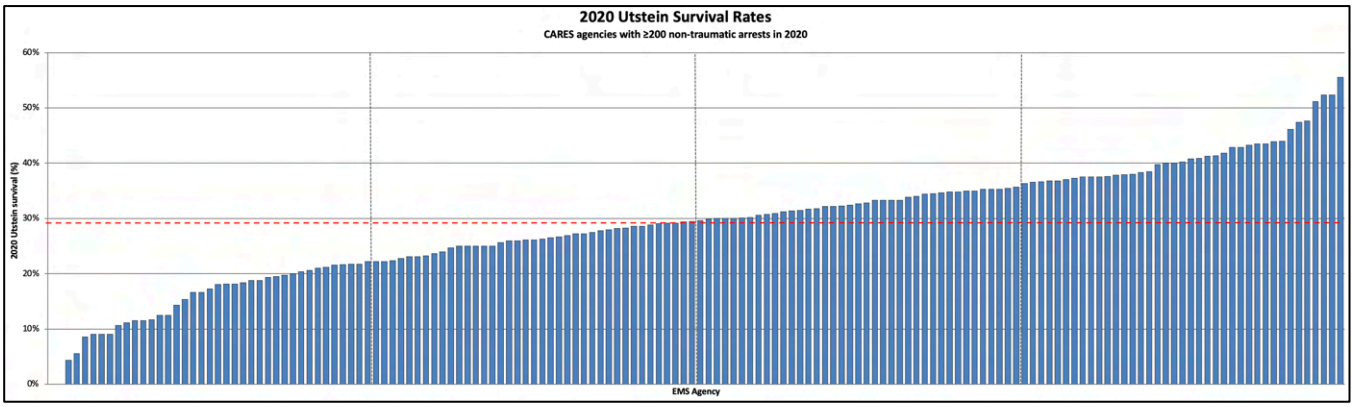


Figure 23. Variability in Utstein survival rates, among EMS agencies with ≥200 CARES cases in 2020.

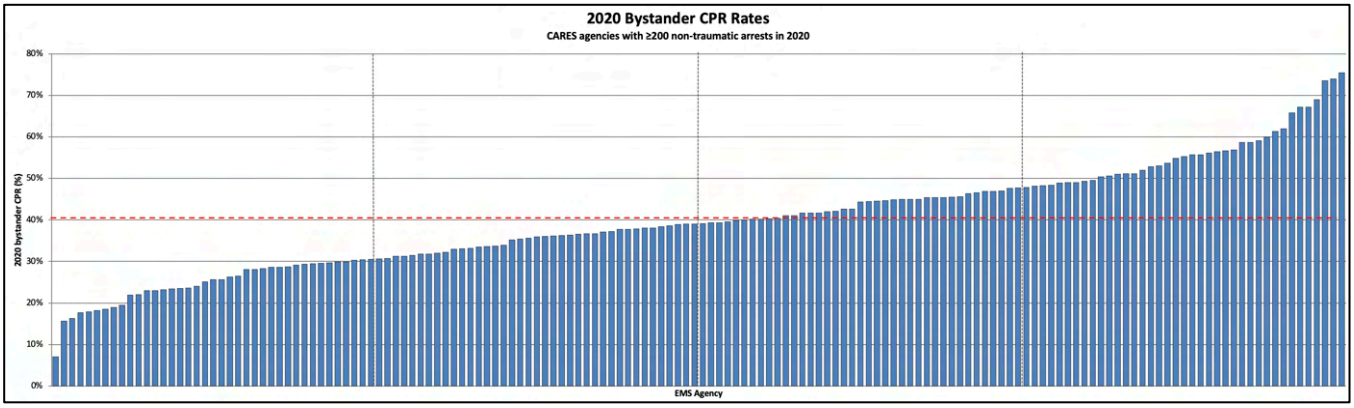


Figure 24. Variability in bystander CPR rates, among EMS agencies with ≥200 CARES cases in 2020.

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 2020. 17 states and the District of Columbia voluntarily agreed to participate in reporting these metrics.

The included states have a wide range of both population catchment (606,242 to over 24 million) as well as incidence rate (44.2–135.5 per 100,000; 3-fold difference). There was also marked variability in community interventions, with bystander CPR rates ranging from 25.8–72.0% (an almost 3-fold difference) and public AED use rates ranging from 3.6–16.3% (a more than 4-fold difference), as well as patient outcomes (overall survival: 4.6–14.6%; Utstein survival: 22.8–37.9%).

	OHCA Incidence					Non-Traumatic Etiology Survival Rates		Bystander Intervention Rates	
	CARES Cases Reported	2020 CARES Population Catchment	2020 Total State Population	% Population Covered	Incidence Rate (per 100,000)	Overall Survival to Hospital Discharge (%)	Utstein Survival (%)	CPR (%)	Public AED Use (%)
National	127,376	143,450,892	328,239,523	43.7%	88.8	9.0	29.2	40.2	9.0
State									
Alaska	474	606,242	731,545	82.9%	78.2	10.1	27.0	72.0	9.7
California	19,908	24,114,025	39,512,223	61.0%	82.6	7.9	29.1	41.8	7.6
Colorado	3,347	5,300,270	5,758,736	92.0%	63.1	13.1	33.2	40.1	7.0
Connecticut	1,817	2,180,601	3,565,287	61.2%	83.3	6.5	25.4	25.8	3.6
Delaware	1,271	973,764	973,764	100.0%	130.5	9.9	34.2	34.8	6.4
Hawaii	1,296	1,415,872	1,415,872	100.0%	91.5	9.4	29.4	45.2	5.2
Michigan	9,290	8,413,271	9,986,857	84.2%	110.4	7.1	27.4	36.2	8.3
Minnesota	3,063	4,567,272	5,639,632	81.0%	67.1	12.4	32.4	37.0	9.4
Mississippi	2,306	2,332,822	2,976,149	78.4%	98.9	6.2	24.7	42.4	7.9
Montana	571	914,114	1,068,778	85.5%	62.5	10.2	31.9	49.6	6.3
Nebraska	694	1,021,561	1,934,408	52.8%	67.9	14.6	33.1	49.1	16.3
North Carolina	7,346	7,918,744	10,488,084	75.5%	92.8	11.5	29.4	42.9	9.5
Oregon	2,677	3,928,444	4,217,737	93.1%	68.1	12.4	29.4	56.0	13.5
Pennsylvania	8,516	9,260,573	12,801,989	72.3%	92.0	8.0	22.8	35.8	10.3
Utah	1,417	3,205,958	3,205,958	100.0%	44.2	9.7	34.5	35.6	9.5
Vermont	517	623,989	623,989	100.0%	82.9	10.3	24.2	53.8	6.2
Washington	4,792	7,333,526	7,614,893	96.3%	65.3	13.7	37.9	56.3	10.9
District of Columbia	956	705,749	705,749	100%	135.5	4.6	31.7	28.0	5.3

Table 4. Public Reporting of State Aggregate Metrics, 2020.

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.

Coronavirus Impact

2020 OHCA metrics

As of May 15, 2021, COVID-19 has infected more than 32 million individuals nationally, causing more than 580,000 deaths[11]. The novel coronavirus has impacted every part of the country. The graph on the left below highlights the newly reported COVID deaths in the US during the 2020 calendar year. The graph on the right below shows the distribution of CARES cases by month during the same time period for comparison.

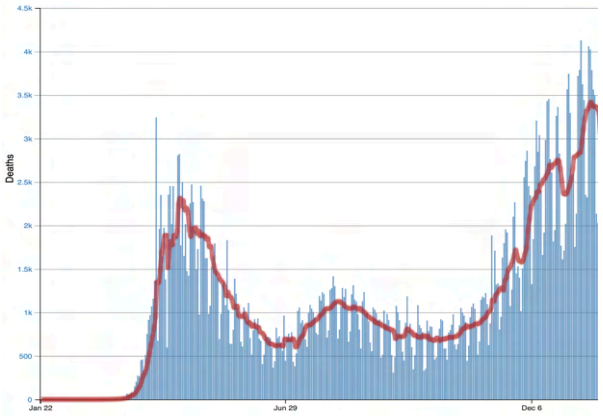


Figure 26. Newly reported COVID-19 deaths in the US by month.

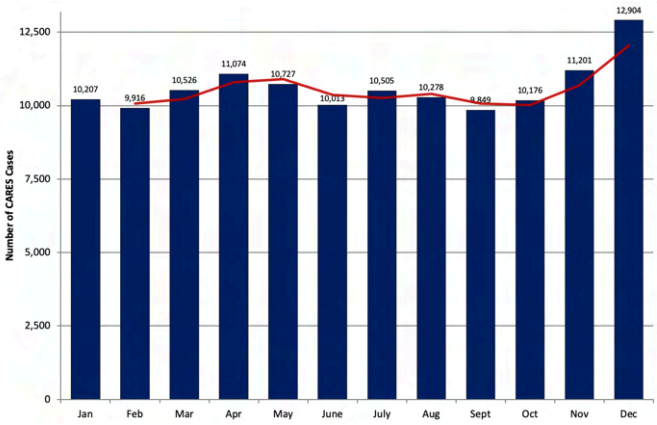


Figure 27. CARES cases by month, 2020.

Over the last year, COVID-19 has transformed the role of local EMS systems, with downstream impacts on resuscitation practices and patient outcomes. As a public health surveillance system, CARES was able to document the impact of COVID-19 on resuscitation practices throughout the country. These data can be used to better understand the needs and challenges of 911 responders in these unprecedented times. The graph on the following page visualizes trends in key OHCA indicators in 2020, representing approximately 10,000 cases each month.

[11] COVID Data Tracker: Trends in Number of COVID-19 Cases and Deaths in the US. Source: CDC.gov.

In summary:

- Public location of arrest decreased from 17.4% to 11.4% over the period from February to April, returning to pre-pandemic levels in June and decreasing once again in November during the second major surge in deaths.
- The proportion of presenting shockable cases followed a similar trend, showing a significant decrease in April and a second dip in November.
- Bystander CPR remained relatively constant throughout the year, but varied by arrest location. Bystander CPR in residential settings remained static (range: 38.4–41.2%). In contrast, bystander CPR in public locations decreased significantly from 47.4% in February to 35.7% in April. While the public bCPR rate rebounded to 45.3% in June, it remained below pre-pandemic levels for the remainder of the year.
- Public AED use decreased from 13.8% to 6.3% during the initial lockdown period, also remaining below pre-pandemic levels for the remainder of the year.
- Field Termination of Resuscitation (TOR) increased significantly from 37.5% in January to 49.7% in April, with the sharpest increase occurring between March and April. While the TOR rate decreased to 41.9% by June, it remained elevated compared to pre-pandemic levels, showing a more gradual increase during the second surge in late fall.

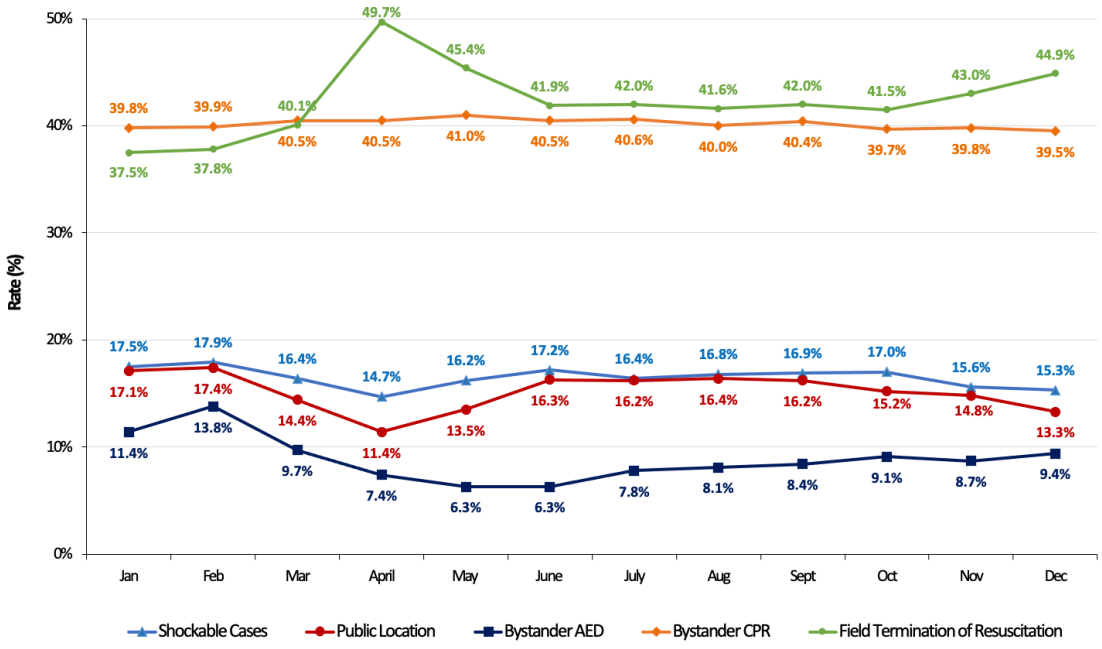


Figure 28. Trends in key OHCA indicators, 2020.

Time to First CPR and Defibrillation

For patients experiencing cardiac arrest, time is the most valuable resource. Early CPR and defibrillation are the third and fourth links in the chain of survival and are most strongly associated with improved outcomes. However, timely intervention for out-of-hospital cardiac arrest patients during the era of COVID-19 presents unique challenges, such as staff shortages, isolation protocols, additional PPE procedures and limited advanced life support resources, all of which can contribute to a delay in CPR and defibrillation.

The below graph (Figure 29) compares the average monthly interval between time of arrest and time of first CPR and defibrillation in 2019 and 2020 for bystander witnessed arrests. Time of first CPR denotes the time of initial cardiopulmonary resuscitation after arrest, including that provided by a bystander, first responder, or EMS personnel. Time of first defibrillation denotes the time of the first defibrillatory shock, administered by either an AED or manual defibrillator.

The average time from arrest to initial CPR was approximately the same for the first quarter of 2019 and 2020. However, the average time to CPR increased between March and April of 2020 (from 6.8 to 7.7 minutes) and remained elevated compared to pre-pandemic levels for the remainder of the year, peaking in September at 8.9 minutes.

Similarly, the average time from arrest to defibrillation in the first three months of 2020 closely mirrored 2019 levels and began to increase in April. Average time to defibrillation was longer in 2020 compared with 2019 for every month thereafter.

These periods of longer time intervals roughly mirror periods when COVID-19 deaths were high, possibly reflective of additional strain on EMS systems and potential delays in patient care.

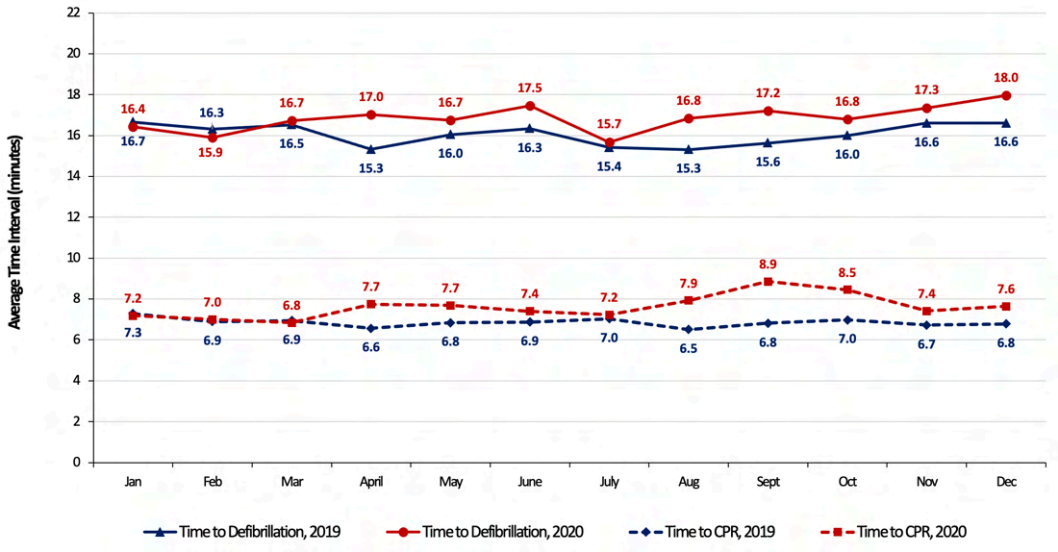


Figure 29. Average interval from time of arrest to first CPR and first defibrillatory shock by month.

Temporal Trends in Patient Outcomes

Survival from OHCA may have been significantly impacted by the COVID-19 pandemic. Potential contributing factors include fewer arrests occurring in public locations, decreased presenting shockable rhythms, lower rates of bystander CPR and defibrillation, changes in patterns of care and post-resuscitation interventions, as well as delays in time-sensitive interventions by bystanders and 911 responders.

Figure 30 highlights monthly trends in survival rates for 2019 and 2020. Similar to other observed metrics, 2020 survival rates remained stable in the first three months of the year, closely mirroring 2019 rates. However, overall survival from April 2020 onwards was considerably lower than in 2019, decreasing from a rate of 9.8% in March to a yearly low of 7.1% in December. Notably, the sharpest decrease occurred between March and April, during the onset of the pandemic.

The second graph (Figure 31) visualizes monthly trends in Utstein survival for 2019 and 2020. While month-to-month variability occurred in both years, Utstein survival was lower in 2020 compared with 2019 for every month except January. Between February and April 2020, the rate of Utstein survival decreased from 30.6% to 27.2%, increasing again in July to 32.3%, and eventually declining to an annual low of 24.7% in December.

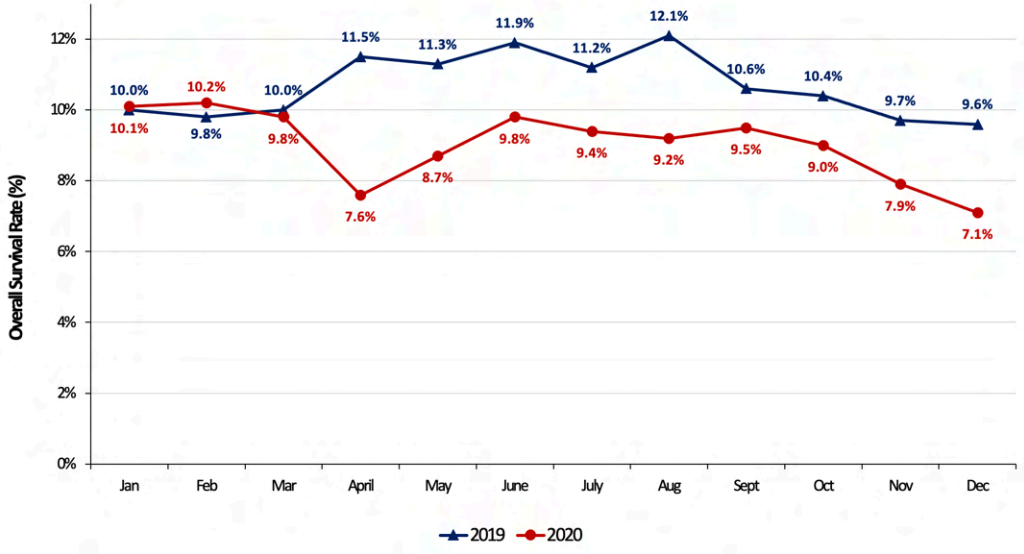


Figure 30. Overall survival by month (2019 vs 2020).

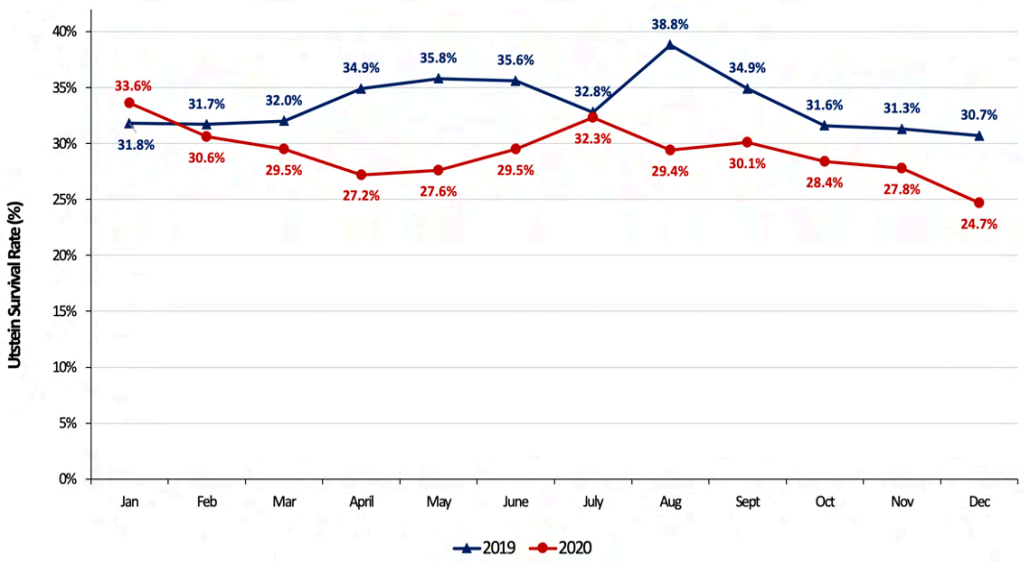


Figure 31. Utstein survival by month (2019 vs 2020).

Drug Overdose Etiology

OHCA caused by drug overdose (OD) is a growing public health concern and a leading cause of death for young adults. According to the Centers for Disease Control and Prevention, overdoses have increased since the start of the pandemic. For those living alone or individuals with underlying mental health conditions, social isolation presents an obvious risk. Additional barriers during the pandemic, such as reduced clinic hours or limited services from community-based organizations, could have exacerbated an already pervasive problem.

During the 2020 pandemic year, there were increases in overdose etiology for all age groups. Tracking OHCA cases from 2019 to 2020, CARES data was used to examine the etiology of arrest over this two-year period. The bar graph below shows the percentage of arrest due to drug overdose across four distinct age groups ≤18, 19-34, 35-49, and ≥50 years old. The most notable of these increases occurred among individuals under 18, for whom the proportion of overdose-related arrests nearly doubled from 3.4% in 2019 to 6.4% in 2020.

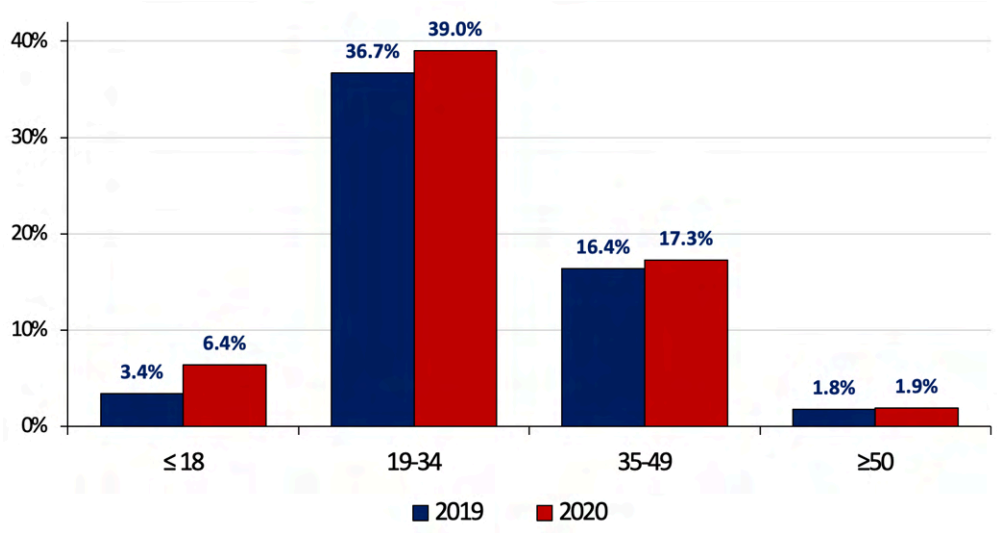


Figure 32. Drug overdose etiology by age group (2019 vs 2020).

Norwalk Hospital EMS personnel in Norwalk, Connecticut demonstrate COVID-19 PPE including full-face P-100 respiratory protection.
Photo courtesy of Norwalk Hospital EMS; Photo credit: Adrian Balikowski.

2020 Research Highlights

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

Peer-Reviewed Publications

- Chan P, Girotra S, Tang Y, Al-Araji R, Nallamothu B, McNally B. **Outcomes for Out-of-Hospital Cardiac Arrest in the United States During the Coronavirus Disease 2019 Pandemic.** *JAMA Cardiol.* 6(3):296-303.
- Coute R, Nathanson B, Kurz M, McNally B, Mader T, The CARES Surveillance Group. **The association between scene time interval and neurologic outcome following adult bystander witnessed out-of-hospital cardiac arrest.** *Am J Emergency Med*. 10:10-16.
- Tobin J, Ramos W, Greenshields J, Dickinson S, Rossano J, Wernicki P, Markenson D, Vellano K, McNally B. **Outcome of Conventional Bystander Cardiopulmonary Resuscitation in Cardiac Arrest Following Drowning.** *Prehosp Disaster Med.* 35(2):141-147.
- Natalzia P, Murk W, Thompson J, Dorsett M, Cushman J, Reed P, Clemency P, The CARES Surveillance Group**. Evidence-based crisis standards of care for out-of-hospital cardiac arrests in a pandemic.** *Resuscitation.* 156:149-156.
- Chan P, McNally B, Vellano K, Tang Y, Spertus JA. **Association of Neighborhood Race and Income With Survival After Out of Hospital Cardiac Arrest.** *J Am Heart Assoc*. 9(4):e014178.
- Kragholm K, Hansen CM, Dupre ME, Strauss B, Tyson C, Monk L, Pearson DA, Nelson RD, Fosbøl EL, Starks M, Jollis JG, Shin J, Rea T, McNally B, Granger CB. **Care and outcomes of urban and non-urban out-of-hospital cardiac arrest patients during the HeartRescue Project in Washington state and North Carolina.** *Resuscitation*. 152:5-15.
- Jones CG, Rappold AG, Vargo J, Cascio WE, Kharrazi M, McNally B, Hoshiko S, and the CARES Surveillance Group. **Out-of-Hospital Cardiac Arrests and Wildfire-Related Particulate Matter During 2015–2017 California Wildfires.** *J Am Heart Assoc*. 9(8):e014125.
- Granfeldt A, Holmberg MJ, Donnino MW, Andersen LW, and the CARES Surveillance Group. **2015 Guidelines for Cardiopulmonary Resuscitation and survival after adult and pediatric out-of-hospital cardiac arrest.** *Eur Heart J Qual Care Clin Outcomes.* 0:1-9.
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- Salhi R, Fouche S, Mendel P, Nelson C, Fetters M, Guetterman T, Forman J, Nham W, Goldstick J, Lehrich J, Forbush B, Iovan S, Hsu A, Shields T, Domeier R, Setodji C, Neumar R, Nallamothu B, Abir M, CARES Surveillance Group. **Enhancing Prehospital Outcomes for Cardiac Arrest (EPOC) study: sequential mixed-methods study protocol in Michigan, USA.** *BMJ***.** 10:e041277.
- Ryan K, Bui M, Dugas J, Zvonar I, Tobin J. **Impact of prehospital airway interventions on outcome in cardiac arrest following drowning: A study from the CARES Surveillance Group.** *Resuscitation*. 163:130-135.
- Tram K, Pressman A, Chen NW, Berger D, Miller J, Welch R, Reynolds J, Pribble J, Hanson I, Swor R. **Percutaneous mechanical circulatory support and survival in patients resuscitated from Out of Hospital cardiac arrest: A study from the CARES surveillance group.** *Resuscitation*. 158:122-129.

Abstracts

- Chan PS, Girotra S, Tang Y, Al-Araji R, Nallamothu B, McNally B. **Outcomes for Out-of-Hospital Cardiac Arrest in the United States During the Coronavirus Disease 2019 Pandemic.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Song J, Berger D, Paxton J, Miller J, Reynolds J, Chen N, Swor R and the CARES Surveillance Group. **Post-Cardiac Arrest Care Variations in Michigan Hospitals and Their Impact on Survival.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Huebinger R, Wang H, Chan H, Panczyk M, Jarvis J, Persse D, Miramontes D, Vithalani V, Schulz K, Troutman G, Greenberg R, Bobrow B. **Community Variations in Out of Hospital Cardiac Arrest Care and Outcomes in Texas**. American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Huebinger R, Wang H, Jarvis J, Decker C, Dickson R, Kidd E, Osborn L, Escott M, White L, Villa N, Bobrow B. **Disparities in Out of Hospital Cardiac Arrest Care and Outcomes in Texas.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Malik A, Jones P, Tran A, Hishoko S, Chan P. **Association of Acute Exposure to Ambient Air Particulate Matter and Ozone with Risk of Out-of-Hospital Cardiac Arrest.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Tran A, Hart A, Spertus J, Jones P, Malik A, Chan P. **A Simple Prognostic Tool for In-Hospital Death in Patients Presenting with Out-of-Hospital Cardiac Arrest and ST-Elevation Myocardial Infarction.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Blewer A, Starks M, Hansen C, Ong M, Viera A, Al-Araji R, McNally B, Granger C. **Gender Disparities in Bystander CPR and Defibrillation Persist in Black and Hispanic Neighborhoods in the US.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Shin J, Chocron R, Rea T, Kudenchuk P, Eisenberg M, McNally B. **Implications of Expanding the Utstein Case Definition for Out of Hospital Cardiac Arrest.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Abir M, Fouche S, Waller V, Entel K, Berri N, Nham W, Forman J, Fetters M, Nelson C, Mendel P, Nallamothu B. **The Enhancing Prehospital Outcomes for Cardiac Arrest (EPOC) study: A Sequential Mixed Methods Study Protocol.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Coute R, Nathanson B, Mader T, McNally B, Kur M. **Annual and Lifetime Economic Productivity Loss Due to Adult Out-of-hospital Cardiac Arrest in the United States.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Tram J, Pressman A, Chen N, Berger D, Miller J, Welch R, Reynolds J, Pribble J, Hanson I, Swor R. **Percutaneous mechanical circulatory support and survival in patients resuscitated from Out of Hospital cardiac arrest: A study from the CARES surveillance group.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Abir M, Fouche S, Lehrich J, Goldstick J, Kamdar N, O'Leary M, Nelson C, Mendel P, Nham W, Setodji C, Domeier R, Hsu A, Shields T, Salhi R, Neumar R, Nallamothu B and the CARES Surveillance Group. **Variation in pre-hospital outcomes after out-of-hospital cardiac arrest in Michigan.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
- Swor R, Berger B, Holt T, Kothari C, Fales W, Reynolds J. **Evaluating Post Arrest Hospital Care For Patients Resuscitated after Out of Hospital Cardiac Arrest Patients in Michigan.** American Heart Association Resuscitation Science Symposium; 2020 November 14-15; Virtual.
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List of 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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