Subject category: Resuscitation Science

Hispanic/Latino-Serving Hospitals Provide Less Targeted Temperature Management Following Out-of-Hospital Cardiac Arrest

Running title: *Morris et al.; Hospital level factors affect access to TTM*

Nicholas A. Morris, MD[1]; Michael Mazzeffi, MD, MPH, MSc[2]; Patrick McArdle, PhD[3]; Teresa L. May, DO[4]; Greer Waldrop, MD[5]; Sarah M. Perman, MD, MSCE[6]; James F. Burke, MD[7], MS; Steven M. Bradley MD, MPH[8]; Sachin Agarwal, MD, MPH[5]; Jose F. Figueroa, MD, MPH[9]; Neeraj Badjatia, MD, MS[1]; with the CARES Surveillance Group

[1]Department of Neurology, Program in Trauma, University of Maryland School of Medicine, Baltimore, MD; [2]Department of Anesthesia, University of Maryland School of Medicine, Baltimore, MD; [3]Departments of Medicine and Epidemiology & Public Health, University of Maryland School of Medicine, Baltimore, MD; [4]Department of Critical Care Services, Maine Medical Center, Portland, ME; [5]Department of Neurology, Columbia University Vagelos College of Physicians and Surgeons, New York, NY; [6]Department of Emergency Medicine, Department of Medicine, Center for Women's Health Research, University of Colorado School of Medicine, Aurora, CO; [7]Department of Neurology, University of Michigan, Ann Arbor, MI; [8]Minneapolis Heart Institute and Minneapolis Heart Institute Foundation, Minneapolis, MN; [9]Department of Health Policy & Management, Harvard T.H. Chan School of Public Health, Boston, MA

Correspondence:
Nicholas A. Morris, MD
Department of Neurology, Program in Trauma
University of Maryland School of Medicine
22 S. Greene St., G7K18, Baltimore, MD 21201
Phone: 410-328-4515/E-mail: nicholas.morris@som.umaryland.edu

Journal Subject Terms: Race and Ethnicity; Cardiopulmonary Arrest; Treatment; Disparities; Health Equity

*Presented in part at the American Heart Association Resuscitation Science Symposium (ReSS), November 12–14, 2021.

Abstract

Background: Variation exists in outcomes following out-of-hospital cardiac arrest (OHCA), but whether racial and ethnic disparities exist in post-arrest provision of targeted temperature management (TTM) is unknown.

Methods and Results: We performed a retrospective analysis of a prospectively collected cohort of patients who survived to admission following OHCA from the Cardiac Arrest Registry to Enhance Survival, whose catchment area represents ~50% of the United States from 2013-2019. Our primary exposure was race/ethnicity and primary outcome was utilization of TTM. We built a mixed-effects model with both state of arrest and admitting hospital modeled as random intercepts to account for clustering. Among 96,695 patients (24.6% Black, 8.0% Hispanic/Latino, 63.4% White), a smaller percentage of Hispanic/Latino patients received TTM than Black or White patients (37.5% vs. 45.0 % vs 43.3%, P < .001) following OHCA. In the mixed-effects model, Black patients (Odds Ratio [OR] 1.153, 95% Confidence Interval [CI] 1.102-1.207, P < .001) and Hispanic/Latino patients (OR 1.086, 95% CI 1.017-1.159, P < .001) were slightly more likely to receive TTM compared to White patients, perhaps due to worse admission neurological status. We did find community level disparity as Hispanic/Latino-serving hospitals (defined as the top decile of hospitals that cared for the highest proportion of Hispanic/Latino patients) provided less TTM (OR 0.587, 95% CI 0.474 to 0.742, P < .001).

Conclusions: Reassuringly, we did not find evidence of intrahospital or interpersonal racial or ethnic disparity in the provision of TTM. However, we did find inter-hospital, community level disparity. Hispanic/Latino-serving hospitals provided less guideline-recommended TTM after OHCA.

Key Words: Cardiac Arrest, Targeted Temperature Management, Race/Ethnicity, Disparities

Non-Standard Abbreviations and Acronyms:

American Heart Association: AHA

Cardiac Arrest Registry to Enhance Survival: CARES

confidence interval: CI

do not resuscitate: DNR

odds ratio: OR

out-of-hospital cardiac arrest: OHCA

return of spontaneous circulation: ROSC

standard deviation: SD

targeted temperature management: TTM

Clinical Perspective

What is New?

- Within hospitals, Black and Hispanic/Latino patients do not receive less targeted temperature management (TTM) than White patients following out-of-hospital cardiac arrest (OHCA).
- Hispanic/Latino-serving hospitals are less likely to provide TTM following OHCA regardless of patient race and ethnicity, resulting in community level disparities in TTM utilization for Hispanic/Latino patients.

What are the Clinical Implications?

- Improving Hispanic/Latino patients' access to advanced post-cardiac arrest care centers may decrease previously described outcome disparities following OHCA.

Large inter-hospital and regional variations exist in outcomes following out-of-hospital cardiac arrest (OHCA).[1] Racial and ethnic disparities contribute to this variation as racial and ethnic minorities have lower rates of neurological recovery.[2-5] Early work on OHCA disparities focused on the pre-hospital and resuscitation phases. Less is known about post-arrest care and disparities therein. Exploring disparities in post-arrest care could have important implications for vulnerable populations and the post-arrest care phase could be another target for improvement.

Targeted temperature management (TTM) is one component of the post-arrest bundle of care that has previously been shown to improve neurologic outcomes after OHCA.[6-8] TTM has been recommended as standard of care for patients following OHCA with both shockable and non-shockable initial rhythms in guidelines by the American Heart Association (AHA) and the European Resuscitation Council,[9; 10] yet TTM was thought to be underutilized.[11-14] Although the recently published TTM2 study failed to show improved outcomes for a target temperature of 33 degrees Celsius vs. normothermia, TTM devices were required per protocol in almost half of the patients in the normothermia arm to treat fever.[15] Thus, while targeting mild hypothermia may not benefit all patients following cardiac arrest, TTM to treat fever will likely remain a critical component of post-cardiac arrest care until proven otherwise. Additionally, the application of post-arrest TTM at a time when it was strongly recommended by guidelines may serve as a proxy for other unmeasured aspects of post-cardiac arrest care. Little is known about racial and ethnic disparities in TTM utilization within the health care system (according to the National Institute on Minority Health and Health Disparities Research Framework).[16] If care for vulnerable populations is to be improved, it is essential to understand both whether disparities truly exist, and the reasons underlying disparities.

In this study, we utilized data from the Cardiac Arrest Registry to Enhance Survival (CARES) to assess for racial and ethnic disparities in utilization of TTM following OHCA. In 2016, the CARES began collecting data about why TTM was not initiated on admission. This supplemental data element provides novel insight and has not previously been reported. We hypothesized that racial or ethnic minorities receive TTM less often than White patients. We also hypothesized that racial or ethnic minorities do not receive TTM for less appropriate reasons than White patients.

Methods

The data that support the findings of this study are available from CARES (cares@emory.edu) upon reasonable request

Design

We performed a retrospective cohort study using CARES data. CARES is a prospectively collected clinical registry for non-traumatic OHCA.[17] The CARES catchment area represents approximately 50% of the US population. Patients with untreated OHCA, bystander suspected OHCA where return of spontaneous circulation (ROSC) was achieved without the need for defibrillation or cardiopulmonary resuscitation, traumatic etiology, or transported by private emergency medical services that do not involve 911 dispatch are not included in the registry. Thus, if a patient does not receive resuscitative efforts due to a known "do not resuscitate" (DNR) order, then they are excluded. Patients experiencing multiple arrests (even if sustained ROSC achieved) are entered as one event. The CARES dataset is geocoded annually and linked to several census tract variables including median household income, unemployment rate, poverty status, urbanicity and educational attainment with data from the American Community Survey 5-year estimates and the 2010 U.S. Census Summary Files. Geographic boundaries are defined by legal areas as of January 1st, 2017.

Participants

We identified all patients 18 years of age and older who survived to admission following OHCA with data regarding race/ethnicity and the use of TTM from January 1, 2013 through December 31, 2019). Study reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies. The local Institutional Review board deemed this study exempt from review as all data was de-identified.

Exposures

Race/ethnicity is identified by the patient, family, or healthcare provider. The source of identification is not included in the registry. In the CARES, race/ethnicity is defined by the US Office of Management and Budget standards.[18] While the US Office of Management and Budget allows for assignment of more than one race, CARES only accepts one answer. Coders are advised to select the most appropriate race/ethnicity for patients

of mixed race, but further directions on how to do this are not offered. It should be noted that persons of Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin are coded as Hispanic/Latino regardless of race. Race/ethnicity data is missing for approximately 25% of patients in CARES because some communities do not collect this information. For the communities that do collect this information, there is virtually no missing data. From census tract data, the racial and ethnic distribution for communities that collect this information is 63% White, 21% Black, 6% Asian, 5% Other Race Alone, 6% Two or More Races compared to 66% White, 12% Black, 10% Asian, 5 % Other Race Alone, 4% Two or More Races for communities that do not collect this information.

Main Outcomes

The primary outcome of interest was utilization of TTM. The CARES registry defines TTM as measures taken to reduce the patient's body temperature either by non-invasive means (i.e. use of cold pack application, cooling blanket, or other surface cooling device) or by invasive means (i.e. intravascular cooling). The registry does collect data regarding the depth, duration, method, or quality of TTM. Importantly, CARES does not include a pre-TTM neurological exam or other measures of TTM eligibility. The secondary outcome of interest was the reason that TTM was not utilized. This optional, supplementary data element was added to the registry in 2016 and is only available for patients that did not receive TTM. Options for this data element included: awake/following commands, Do-Not-Resuscitate (DNR)/family request, unwitnessed cardiac arrest, non-shockable rhythm, no TTM program in place, other, and unknown.

Statistical Analysis

Statistical analysis was performed using SPSS 26.0 (IBM Corporation, Armonk, NY, USA). Univariate associations between patient characteristics (age, sex, race/ethnicity), cardiac arrest characteristics (year of arrest, initial rhythm, witnessed, bystander CPR, etiology), hospital characteristics (type, size, urbanicity), and neighborhood characteristics (urbanicity, unemployment rate, poverty level) with TTM utilization were tested using Pearson's chi-square statistic, Student t test, or Wilcoxon's rank sum test, as appropriate for variable type and distribution of data. Urbanicity was described according to 2010 Census File definitions with

Urbanized areas having 50,000 people or more, urban clusters having 2,500-49,999 people, and rural areas including all populations not included within an urban area.

We aimed to ascertain the domain of influence of a potential disparity according to the National Institute on Minority Health and Health Disparities Research Framework. We built a mixed-effects model to estimate patient level (age, sex. race/ethnicity), arrest level (shockable vs. non-shockable initial rhythm, witnessed vs. unwitnessed, etiology of arrest), hospital level (type of hospital, hospital size), and neighborhood-level (urban-rural designation, percent below poverty level, unemployment rate, number of persons with high school degree or higher) factors associated with TTM utilization. State of admission and admitting hospital were modeled as random effects to account for clustering. Because the unadjusted rates of TTM showed that Hispanic/Latino patients received less TTM overall, we were also interested in whether Hispanic/Latino-serving hospitals used less TTM. We defined Hispanic/Latino-serving hospitals by first ranking all hospitals by the proportion of their patients in the registry who were Hispanic/Latino. We then defined the top 10% of hospitals with the highest proportion of Hispanic/Latino patients as "Hispanic/Latino-serving hospitals" as has been done previously.[19; 20] Notably, the top 10% of hospitals cared for 47% of all Hispanic/Latino patients in the registry. The remaining 90% of hospitals were defined as non-Hispanic/Latino-serving hospitals. Patients who were missing data for variables that were selected a priori to be included in the mixed effects regression model were excluded from the analysis (< 3% of patients).

In an exploratory analysis, we compared the reasons that TTM was not utilized for the period for which this data was available (2016-2019) by race/ethnicity using Pearson's chi-square statistic. Proportions of each race/ethnicity were compared per reason that TTM was not utilized with Bonferroni correction for multiple comparisons.

Because we were particularly interested in disparities in the application of TTM towards patients who *should* have received the therapy, we performed a sensitivity analysis excluding all patients that did not receive TTM because they were awake/following commands, as these patients would not be eligible for TTM, limited to 2016-2019 when this data was made available. We performed this sensitivity analysis separately for our primary analysis evaluating TTM utilization and for our secondary analysis evaluating the reasons given by participating centers regarding why patients did not receive TTM.

We finally assessed for temporal trends in utilization of TTM for Black patients vs. Hispanic/Latino patients vs. White patients by fitting a generalized linear mixed model with annual TTM utilization data from 2013-2019.

For the trends analysis we included only data from hospitals that contributed cases over the entire course of the study to reduce variation of adding new hospitals to the case mix. We compared the slopes for Black patients vs. Hispanic/Latino patients vs. White patients by testing for interaction with a linear time term.

Results

Among 457,621 patients in the registry, we identified 96,695 patients [mean (standard deviation (SD)) age 61.4 (16.3) years, 40.0% women, 24.6% Black, 8.0% Hispanic/Latino, 63.4% White] that survived to hospital admission following OHCA (Figure 1). Most OHCAs occurred at home (65.3%), followed by in public (21.9%), and at nursing homes/healthcare facilities (12.8%). White patients had the highest rates of shockable rhythms and bystander CPR (Table 1). A higher percentage of Black patients were cared for in major teaching hospitals (34.5%) compared to Hispanic/Latino patients (18.9%) and White patients (18.7%) (Table 2). A higher percentage of Black patients received TTM than White patients and Hispanic/Latino patients (45.0% vs. 43.3% vs. 37.5%, P < .001).

In univariate analysis (Tables S1 and S2), Patients who received TTM were slightly younger (mean (SD) 60 (16) years vs. 62 (17) years, P value < .001) and had a higher percentage of cardiac etiology of OHCA (80.7% vs. 76.5%, P < .001). Patients who received TTM also had a higher percentage of shockable rhythms (38.3% vs. 28.6%, P < .001), had TTM initiated in the field more often (18.8% vs. 9.6%, P < .001), and more often received care in teaching hospitals (83.4% vs. 77.2%, P < .001).

In a mixed-effects model controlling for patient, hospital, and neighborhood level factors with the state of arrest and admitting hospital modeled as random effects, Hispanic/Latino patients and Black patients were more likely than White patients to receive TTM (odds ratio [OR] for Hispanic/Latino patients 1.086, 95% confidence interval [CI] 1.017 to 1.159, P < .001, and OR for Black patients 1.153, 95% CI 1.102 to 1.207, P < .001). In contrast, patients receiving care in Hispanic/Latino-serving hospitals were less likely to receive TTM (OR 0.587, 95% CI 0.474 to 0.742, P < .001). Hispanic/Latino-serving hospitals cared for 47% of Hispanic-Latino patients and less than eight percent of patients from other races/ethnicities in CARES.

Older age, female sex, and non-shockable initial rhythm were also associated with not receiving TTM (Table 3). Conversely, cardiac or respiratory etiologies (as opposed to drug overdose), unwitnessed arrest,

urbanized neighborhoods, and teaching hospital categorization were all associated with TTM utilization. Our results were similar in a sensitivity analysis excluding patients who were awake/following commands and limited to the period for which that data was available (Table S3).

Data were available regarding why patients did not receive TTM (Table 4) for 22,896 patients (57.5.% of the cohort that did not receive TTM following introduction of the data element in 2016). Higher percentages of Hispanic/Latino patients and Black patients compared to White patients did not receive TTM due to absence of a TTM program (4.0% vs. 2.5% vs. 1.8%, $p < .001$). Hispanic/Latino patients and Black patients also had higher percentages of not receiving TTM than White patients due to unwitnessed arrests and unknown reasons. A higher percentage of Black patients than White patients did not receive TTM due to non-shockable rhythms and other reasons not specified (Table 4). Our results were consistent in a sensitivity analysis excluding patients that were noted to not receive TTM due to being awake/following commands from 2016-2019 (Table S4).

Trends analysis of 60,309 patients from 375 hospitals that contributed data to the CARES registry for the full duration of the study revealed a significant linear trend in the rate of TTM over time for all races/ethnicities. There were no interactions between race/ethnicity and time after adjusting for multiple comparisons (Figure 2).

Discussion

We found community level health care system disparities in TTM utilization in a large, prospectively collected OHCA registry. In unadjusted comparison, Hispanic/Latino patients received less TTM following OHCA than Black patients or White patients. Reassuringly, when we looked within a given hospital to assess for interpersonal health care disparities, we did not find any difference in the utilization of TTM according to race/ethnicity. In fact, within a given hospital Hispanic/Latino patients and Black patients were even more likely than White patients to receive TTM. However, we found that Hispanic/Latino-serving hospitals provided less TTM following OHCA. This explains why Hispanic/Latino patients received less TTM overall despite being just as likely or more likely to receive TTM within a given hospital. In a secondary analysis, for the subset of patients with data regarding why they did not receive TTM, Hispanic/Latino patients had the

highest percentage of not receiving TTM due to the absence of a TTM program – supporting our primary result. We did not find any trends in TTM utilization by race/ethnicity over time.

Our major finding is that patients in Hispanic/Latino-serving hospitals deliver less TTM even when controlling for arrest features and other hospital characteristics. This finding suggests that Hispanic/Latino patients lack access to hospitals with advanced post-cardiac arrest care resources. An alternative explanation could be that Hispanic/Latino patients lack access to hospitals that offer high-quality, guideline concordant care independent of resource availability. Our findings are akin to previous studies that have found Hispanic/Latino patients lack access to critical, time-sensitive interventions such as percutaneous cardiac interventions for myocardial infarction and mechanical thrombectomy for ischemic stroke.[21; 22]

The responses from a novel data element exploring why TTM was not offered support the primary result. CARES contributors reported that a higher percentage of Hispanic/Latino patients compared to other races/ethnicities did not receive TTM due to the lack of a TTM program at the admitting hospital, although this finding was based on a small number of patients (73/1826 Hispanic/Latino patients vs. vs. 123/855 Black patients vs. 270/4663 White patients). In addition, we found large effects of other hospital characteristics on delivery of TTM in our primary analysis. Together these results argue for the development of regionalized approaches to post-cardiac arrest care that includes transport to specialized cardiac arrest centers where TTM is routinely delivered, as has been recommended by recent AHA guidelines.[23] Implementation of such an approach in Arizona led to increased provision of TTM and improved survival and neurological outcomes.[24] Further study is warranted to see if direct transport of all patients following OHCA to specialized cardiac arrest centers reduces disparities in TTM utilization and improves outcomes.

Within similar hospitals, Black and Hispanic/Latino patients were actually more likely to receive TTM following OHCA. This finding is consistent with registry data from Los Angeles County Emergency Medical Services.[25] We posit that Black and Hispanic/Latino patients are more likely to be comatose on arrival, thus increasing their rates of eligibility for TTM. Meta-analysis has previously shown that Black patients are less likely than White patients to survive to hospital admission.[3] Those that do survive to admission may be more likely to be comatose. Less is known about the relative survival rates of Hispanic/Latino patients, but data from the Resuscitation Outcomes Consortium show that those that suffer OHCA in predominantly Hispanic/Latino neighborhoods receive bystander CPR less often and have worse survival to admission.[26] In our study, Black and Hispanic/Latino patients received bystander CPR in fewer cases compared to White patients. Further

supporting our supposition, we found that 30% of White patients did not receive TTM due to being awake/following commands while only 17% of Black and Hispanic/Latino patients did not receive TTM for the same reason. Surprisingly, neurological status on admission is lacking from large OHCA datasets, challenging the interpretation of post-cardiac arrest care effects on discharge neurological outcomes.

It must be noted that the recent TTM2 Trial did not find a benefit in mortality or neurological outcomes for TTM compared to targeted normothermia with early treatment of fever.[15] Those findings likely lessen the clinical impact of our findings. However, in TTM2 46% of the normothermia group received active cooling with a temperature management device per protocol for fever management. Thus, the TTM2 study does not exonerate hospitals from providing TTM resources to post-cardiac arrest patients who develop fever.

Furthermore, TTM during the study period that we examined (2013-2019) was standard of care for post-cardiac arrest patients. It is problematic that Hispanic/Latino-serving hospitals were less likely to deliver the standard of care at the time, regardless of whether the standard of care has changed. The provision of TTM during that period may serve as a proxy for other non-measured aspects of excellent post-cardiac arrest care such as optimization of hemodynamics, oxygenation, and ventilation, and accurate protocolized multimodal neuroprognostication.[9; 10] Perhaps these unmeasured confounders explain why some retrospective studies of TTM show a benefit.[27] Future studies should investigate whether disparities exist in these components of the post-cardiac arrest care bundle.

Importantly, prior studies have found that both Black patients and Hispanic/Latino patients are less likely than White patients to receive coronary angiography and percutaneous coronary intervention following OHCA when an acute coronary syndrome is suspected, despite guideline recommendations.[28; 29] Eligible Black patients may also be less likely to receive implantable cardioverter-defibrillators following cardiac arrest.[28] An analysis of the Get With The Guidelines-Heart Failure Program found that Black patients and Hispanic/Latino patients are less likely to receive implantable cardioverter-defibrillators when indicated for heart failure as compared to White patients.[30] Whether or not these findings are due to access issues warrants further investigation.

There are several important limitations to our study. Foremost, we lacked comprehensive TTM eligibility criteria for all patients, including patient comorbidities, time to ROSC, and post-resuscitation neurologic status in all patients. Without this data, as well as appropriately timed follow-up, we were unable to evaluate the effect of TTM disparities on neurological outcomes. Nonetheless, we did have novel data in 22,898

patients regarding the reasons that TTM, an intervention with a strong Class I recommendation from the AHA following OHCA, was not utilized. We also performed a sensitivity analysis limited to patients most likely to receive TTM and found that disparities remained in the reasons why patients did not receive TTM. Second, our analysis was restricted by the US Office of Management and Budget standards and the decision of the CARES registry to allow selection of only one race/ethnicity. As such, we were not able to assess disparities among more specific racial and ethnic groups such as non-Hispanic Black, Hispanic Black, Hispanic White. It is also uncertain how many patients or patients' families identified their own race/ethnicity; thus, some patients' race/ethnicity may have been incorrectly assigned. Moreover, due to relatively low numbers, we were unable to evaluate disparities in other races/ethnicities. Third, data regarding race/ethnicity is missing in 25% of patients within the CARES database as some communities systematically do not collect this information. These patients were excluded from our analysis, and it is unknown if this biased our results. We believe, however, that bias is less likely since those contributors to CARES systematically do not report race/ethnicity.

Conclusions

Hispanic/Latino patients received TTM less often following OHCA than Black or White patients. We found no evidence of intrahospital racial or ethnic disparity (interpersonal disparity) in the provision of TTM. In fact, within a given hospital Hispanic/Latino patients and Black patients received TTM more often, likely due to worse admission neurological status. However, we did find inter-hospital, community level disparity. Patients in Hispanic/Latino-serving hospitals received TTM less often after OHCA, regardless of race/ethnicity. Because nearly half of Hispanic/Latino patients receive care in Hispanic/Latino-serving hospitals, they received less TTM. Efforts to decrease racial and ethnic outcomes disparities following OHCA may include improving access to advanced post-cardiac arrest care for Hispanic/Latino patients, perhaps through the development of regional cardiac arrest centers.

Acknowledgements: The CARES Surveillance Group comprises all members of contributing EMS agencies and hospitals. We would like to acknowledge their contributions, although we are unable to individually list all of the members, as CARES includes individuals from the 1800+ EMS agencies and 2000+ hospitals that

participate in the registry. The authors are also grateful to E. John Orav, PhD, who provided statistical expertise.

Sources of Funding: None.

Disclosures: Dr. Mazzeffi serves on the advisory board for Hemosonics and has received consulting fees. Dr. May received significant funding from the National Institute of General Medical Sciences 1P20GM139745-01. Dr. Perman received significant funding from the National Heart, Lung, and Blood Institute K23 HL138164. Dr. Burke received significant funding from the National Institute on Aging R01 AG059733 and the National Institute on Minority Health and Health Disparities R01 MD008879. Dr. Agarwal received significant funding from the National Heart, Lung, and Blood Institute R56/R01 HL153311. The remaining authors have no disclosures to report.

Supplemental Material: Tables S1-S4.

References:

1. Nichol G, Thomas E, Callaway CW, Hedges J, Powell JL, Aufderheide TP, Rea T, Lowe R, Brown T, Dreyer J et al. Regional variation in out-of-hospital cardiac arrest incidence and outcome. JAMA. 2008; 300:1423-1431.
2. Casey SD, Mumma BE. Sex, race, and insurance status differences in hospital treatment and outcomes following out-of-hospital cardiac arrest. Resuscitation. 2018; 126:125-129.
3. Shah KS, Shah AS, Bhopal R. Systematic review and meta-analysis of out-of-hospital cardiac arrest and race or ethnicity: Black us populations fare worse. Eur J Prev Cardiol. 2014; 21:619-638.
4. Becker LB, Han BH, Meyer PM, Wright FA, Rhodes KV, Smith DW, Barrett J. Racial differences in the incidence of cardiac arrest and subsequent survival. The cpr chicago project. N Engl J Med. 1993; 329:600-606.

5. Agarwal S, Presciutti A, Roth W, Matthews E, Rodriguez A, Roh DJ, Park S, Claassen J, Lazar RM. Determinants of long-term neurological recovery patterns relative to hospital discharge among cardiac arrest survivors. Crit Care Med. 2018; 46:e141-e150.
6. Bernard SA, Gray TW, Buist MD, Jones BM, Silvester W, Gutteridge G, Smith K. 2002. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N Engl J Med. 2002; 346:557-563.
7. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N Engl J Med. 2002; 346:549-556.
8. Lascarrou JB, Merdji H, Le Gouge A, Colin G, Grillet G, Girardie P, Coupez E, Dequin PF, Cariou A, Boulain T et al. Targeted temperature management for cardiac arrest with nonshockable rhythm. N Engl J Med. 2019; 381:2327-2337.
9. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, Kudenchuk PJ, Kurz MC, Lavonas EJ, Morley PT et al. Part 3: Adult basic and advanced life support: 2020 american heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020; 142:S366-S468.
10. Nolan JP, Sandroni C, Böttiger BW, Cariou A, Cronberg T, Friberg H, Genbrugge C, Haywood K, Lilja G, Moulaert VRM et al. European resuscitation council and european society of intensive care medicine guidelines 2021: Post-resuscitation care. Resuscitation. 2021; 161:220-269.
11. Abella BS, Rhee JW, Huang KN, Vanden Hoek TL, Becker LB. Induced hypothermia is underused after resuscitation from cardiac arrest: A current practice survey. Resuscitation. 2005; 64:181-186.
12. Bigham BL, Dainty KN, Scales DC, Morrison LJ, Brooks SC. Predictors of adopting therapeutic hypothermia for post-cardiac arrest patients among canadian emergency and critical care physicians. Resuscitation. 2010; 81:20-24.
13. Patel PV, John S, Garg RK, Temes RE, Bleck TP, Prabhakaran S. Therapeutic hypothermia after cardiac arrest is underutilized in the united states. Ther Hypothermia Temp Manag. 2011; 1:199-203.
14. Bradley SM, Liu W, McNally B, Vellano K, Henry TD, Mooney MR, Burke MN, Brilakis ES, Grunwald GK, Adhaduk M et al. Temporal trends in the use of therapeutic hypothermia for out-of-hospital cardiac arrest. JAMA Netw Open. 2018; 1:e184511.

15. Dankiewicz J, Cronberg T, Lilja G, Jakobsen JC, Levin H, Ullén S, Rylander C, Wise MP, Oddo M, Cariou A et al. Hypothermia versus normothermia after out-of-hospital cardiac arrest. N Engl J Med. 2021; 384:2283-2294.
16. Nimhd research framework. 2017. [accessed 2021 July 29th]. https://www.nimhd.nih.gov/about/overview/research-framework/nimhd-framework.html.
17. McNally B, Stokes A, Crouch A, Kellermann AL, Group CS. Cares: Cardiac arrest registry to enhance survival. Ann Emerg Med. 2009; 54:674-683.e672.
18. Office of Budget and Management. Revisions to the standards for the classification of federal data on race and ethnicity. Federal Register. 1997; 62:58782-58790.
19. Cole AP, Nguyen DD, Meirkhanov A, Golshan M, Melnitchouk N, Lipsitz SR, Kilbridge KL, Kibel AS, Cooper Z, Weissman J et al. Association of care at minority-serving vs non-minority-serving hospitals with use of palliative care among racial/ethnic minorities with metastatic cancer in the united states. JAMA Netw Open. 2019; 2:e187633.
20. Figueroa JF, Reimold KE, Zheng J, Orav EJ. Differences in patient experience between hispanic and non-hispanic white patients across u.S. Hospitals. J Healthc Qual. 2018; 40:292-300.
21. Hsia RY, Shen YC. Percutaneous coronary intervention in the united states: Risk factors for untimely access. Health Serv Res. 2016; 51:592-609.
22. Rinaldo L, Rabinstein AA, Cloft H, Knudsen JM, Castilla LR, Brinjikji W. Racial and ethnic disparities in the utilization of thrombectomy for acute stroke. Stroke. 2019; 50:2428-2432.
23. Panchal AR, Berg KM, Cabañas JG, Kurz MC, Link MS, Del Rios M, Hirsch KG, Chan PS, Hazinski MF, Morley PT et al. 2019 american heart association focused update on systems of care: Dispatcher-assisted cardiopulmonary resuscitation and cardiac arrest centers: An update to the american heart association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2019; 140:e895-e903.
24. Spaite DW, Bobrow BJ, Stolz U, Berg RA, Sanders AB, Kern KB, Chikani V, Humble W, Mullins T, Stapczynski JS et al. Statewide regionalization of postarrest care for out-of-hospital cardiac arrest: Association with survival and neurologic outcome. Ann Emerg Med. 2014; 64:496-506.e491.
25. Bosson N, Fang A, Kaji AH, Gausche-Hill M, French WJ, Shavelle D, Thomas JL, Niemann JT. Racial and ethnic differences in outcomes after out-of-hospital cardiac arrest: Hispanics and blacks may fare worse than non-hispanic whites. Resuscitation. 2019; 137:29-34.

26. Blewer AL, Schmicker RH, Morrison LJ, Aufderheide TP, Daya M, Starks MA, May S, Idris AH, Callaway CW, Kudenchuk PJ et al. Variation in bystander cardiopulmonary resuscitation delivery and subsequent survival from out-of-hospital cardiac arrest based on neighborhood-level ethnic characteristics. Circulation. 2020; 141:34-41.

27. Callaway CW, Schmicker RH, Brown SP, Albrich JM, Andrusiek DL, Aufderheide TP, Christenson J, Daya MR, Falconer D, Husa RD et al. Early coronary angiography and induced hypothermia are associated with survival and functional recovery after out-of-hospital cardiac arrest. Resuscitation. 2014: 85:657-663.

28. Groeneveld PW, Heidenreich PA, Garber AM. Racial disparity in cardiac procedures and mortality among long-term survivors of cardiac arrest. Circulation. 2003; 108:286-291.

29. Patel N, Patel NJ, Macon CJ, Thakkar B, Desai M, Rengifo-Moreno P, Alfonso CE, Myerburg RJ, Bhatt DL, Cohen MG. Trends and outcomes of coronary angiography and percutaneous coronary intervention after out-of-hospital cardiac arrest associated with ventricular fibrillation or pulseless ventricular tachycardia. JAMA Cardiol. 2016: 1:890-899.

30. Hess PL, Hernandez AF, Bhatt DL, Hellkamp AS, Yancy CW, Schwamm LH, Peterson ED, Schulte PJ, Fonarow GC, Al-Khatib SM. Sex and race/ethnicity differences in implantable cardioverter-defibrillator counseling and use among patients hospitalized with heart failure: Findings from the get with the guidelines-heart failure program. Circulation. 2016; 134:517-526.

Table 1. Patient and cardiac arrest characteristics of out-of-hospital cardiac arrests, stratified by race/ethnicity.

	Black (N=23801)	Hispanic/Latino (N=7748)	White (N=61281)	Other (N=3818)
Age, mean (SD), y	60.9 (15.4)	58.8 (17.0)	61.8 (16.5)	64.3 (17.0)
Women	11204 (47.0)	2804 (36.2)	22805 (37.2)	1447 (37.9)
Year of Arrest				
2013	1614 (6.8)	723 (9.3)	4266 (7.0)	313 (8.2)
2014	2081 (8.7)	771 (9.9)	5758 (9.4)	377 (9.9)
2015	2554 (10.7)	887 (11.4)	7046 (11.5)	446 (11.7)
2016	3225 (13.5)	919 (11.9)	8390 (13.7)	520 (13.6)
2017	4190 (17.6)	1106 (14.3)	10241 (16.7)	608 (15.9)
2018	4744 (19.9)	1404 (18.1)	11675 (19.0)	722 (18.9)
2019	5407 (22.7)	1940 (25.0)	13934 (22.7)	834 (21.8)
Arrest Witnessed	16181 (67.9)	5080 (65.5)	42080 (68.6)	2637 (69.0)
Initiated CPR				
EMS	9816 (41.2)	2632 (34.0)	19156 (31.2)	1262 (33.0)
First responder	6110 (25.7)	2094 (27.0)	15569 (25.4)	882 (23.1)
Lay person	7867 (33.0)	3006 (38.8)	26427 (43.1)	1673 (43.8)
Not Applicable	22 (0.1)	18 (0.2)	153 (0.2)	1262 (0.1)
Shockable Rhythm	6042 (25.4)	2100 (27.1)	22415 (36.6)	1173 (30.7)
Received TTM in field	3395 (14.3)	1203 (15.5)	8103 (13.2)	463 (12.1)
Received TTM in hospital	10728 (45.0)	2907 (37.5)	26573 (43.3)	1800 (47.1)
Diagnosed MI*	2602 (10.9)	938 (12.1)	12228 (19.9)	570 (14.9)
Etiology of Arrest				
Cardiac	19102 (80.2)	6322 (81.6)	47259 (77.1)	3056 (80.0)
Respiratory/asphyxia	3310 (13.9)	822 (10.6)	7950 (13.0)	500 (13.1)
Drug overdose	784 (3.3)	319 (4.1)	3389 (5.5)	48 (1.3)
Other	619 (2.6)	287 (3.7)	2712 (4.4)	216 (5.7)

Made DNR in Hospital	5286 (22.2)	1438 (18.6)	14762 (24.1)	754 (19.7)
Survived to Discharge	8316 (34.9)	2503 (32.3)	24027 (39.2)	1198 (31.4)
Neurologic Outcome				
Good cerebral performance	3738 (15.7)	1356 (17.5)	16054 (26.2)	686 (18.0)
Moderate disability	1527 (6.4)	428 (5.5)	4203 (6.9)	242 (6.3)
Severe disability	2083 (3.4)	290 (3.7)	2083 (3.4)	135 (3.5)
Coma, vegetative state, or death	17231 (72.4)	5676 (73.3)	38970 (63.5)	2757 (72.1)

All values presented as n (%) unless otherwise specified.

*Supplementary variable that is not available for all patients

TTM: Targeted Temperature Management; SD: Standard Deviation; CPR: Cardiopulmonary Resuscitation; MI: Myocardial Infarction; DNR: Do Not Resuscitate

Table 2. Hospital and neighborhood characteristics of out-of-hospital cardiac arrests, stratified by race/ethnicity.

	Black (N=23801)	**Hispanic/Latino (N=7748)**	**White (N=61281)**	**Other (N=3818)**
Type of Hospital				
Major teaching	8213 (34.5)	1463 (18.9)	11489 (18.7)	514 (13.5)
Minor teaching	12170 (51.1)	4600 (59.4)	37163 (60.6)	2496 (65.3)
Non-teaching	2775 (11.7)	1175 (15.2)	11544 (18.8)	698 (18.3)
No data	657 (2.8)	512 (6.6)	1114 (1.8)	112 (2.9)
Urban-Rural Designation of Hospital*				

Urbanized area	22955 (96.4)	3492 (91.4)	58040 (94.7)	3492 (91.4)
Urban cluster	411 (1.7)	83 (1.1)	2532 (4.1)	215 (5.6)
Rural	56 (0.2)	9 (0.1)	407 (0.7)	21 (0.5)
No data	393 (1.7)	261 (3.4)	331 (0.5)	92 (2.4)
Hospital size				
Up to 250 beds	6656 (27.9)	2305 (29.7)	20567 (33.5)	1623 (42.5)
251-500 beds	8282 (34.8)	2688 (34.7)	22514 (36.7)	1447 (37.9)
501-750 beds	4535 (19.0)	1414 (18.2)	11776 (19.2)	526 (13.9)
More than 750 beds	3684 (15.5)	831 (10.7)	5334 (8.7)	112 (2.9)
No data	659 (2.8)	512 (6.6)	1119 (1.8)	112 (2.9)
Hispanic/Latino-Serving Hospital	1797 (7.5)	3650 (47.1)	3462 (5.6)	291 (7.6)
Urban-Rural designation of neighborhood				
Urbanized area	22456 (94.3)	7323 (94.5)	50510 (82.4)	3393 (88.8)
Urban cluster	4240 (6.9)	239 (3.1)	4240 (6.9)	217 (5.7)
Rural	716 (3.0)	169 (2.3)	6392 (10.4)	189 (4.9)
No data	59 (0.2)	19 (0.2)	168 (0.3)	21 (0.5)
Unemployment rate of neighborhood (%) [IQR]	8.3 (8.1)	6.6 (5.7)	5.0 (4.2)	5.1 (4.3)
Percent below poverty level of neighborhood				
< 10%	4488 (18.8)	1655 (21.4)	27150 (44.3)	1716 (44.9)
10% - 20%	6328 (26.6)	2366 (30.5)	20000 (32.6)	9.7 (3.7)
20% - 30%	5573 (23.4)	1979 (25.5)	8421 (13.7)	588 (15.4)
> 30%	7311 (30.7)	1703 (22.0)	5379 (8.8)	371 (9.7)
No data	115 (0.5)	47 (0.6)	360 (0.6)	40 (1.0)
Total persons with high school diploma or higher	2584 (1590)	2749 (1577)	3176 (1745)	3256 (1670)

in census tract, mean (SD)

All values presented as n (%) unless otherwise specified.

*Source: 2010 Census Summary File, Variable: P2 (Urban and Rural), Census Tract-Level Data

SD: Standard Deviation

Table 3. Mixed effects model for utilization of targeted temperature management, with state of arrest and hospital modeled with a random intercept*.

	Odds Ratio (95 % Confidence Interval)	P value
Age (per year)	0.991 (0.990, 0.992)	< .001
Women (compared to men)	0.914 (0.887, 0.943)	< .001
Race/Ethnicity		
White	Reference	< .001
Black	1.153 (1.102, 1.207)	
Hispanic/Latino	1.086 (1.017, 1.159)	
Other	1.072 (0.992, 1.158)	
Arrest Unwitnessed	1.206 (1.163, 1.250)	< .001
Nonshockable Rhythm	0.668 (0.631, 0.708)	< .001
Etiology of Arrest		
Cardiac	Reference	< .001
Respiratory/asphyxia	0.908 (0.860, 0.960)	
Drug Overdose	0.593 (0.540, 0.651)	
Other	0.534 (0.492, 0.581)	
Neighborhood Urbanicity		
Rural	Reference	< .001
Urban cluster	0.898 (0.828, 0.974)	
Urbanized area	1.076 (1.013, 1.144)	

Type of Hospital		
Major teaching	Reference	< .001
Minor teaching	0.846 (0.707, 1.013)	
Non-teaching	0.586 (0.468, 0.734)	
Hospital Size		
Up to 250 beds	Reference	.03
251-500 beds	1.227 (1.070, 1.408)	
501-750 beds	1.074 (0.869, 1.329)	
More than 750 beds	1.207 (0.909, 1.603)	
Hispanic/Latino-serving-hospital	0.587 (0.474, 0.742)	< .001
Percent below poverty level		
>30%	Reference	.29
20% - <30%	0.968 (0.911, 1.030)	
10% - <20%	0.982 (0.924, 1.043)	
<10%	0.953 (0.894, 1.016)	
Unemployment rate of neighborhood (per 1%)	1.003 (0.999, 1.007)	.11
Persons with high school degree or higher (per person)	1.000 (1.000, 1.000)	.48

*Generalized linear mixed model where state in which arrest occurred and hospital were modeled as random effects. Coefficients are shown for fixed effects in the model.

Table 4. Reasons targeted temperature management was not utilized (data collected since 2016).

	Awake / Following Commands (N = 6003)	DNR / Family Request (N = 2950)	No TTM Program in Place (N = 478)	Non-shockable Rhythm (N = 2170)	Unwitnessed Cardiac Arrest (N = 1786)	Other (N = 5938)	Unknown (N = 3573)
Black	855 (17.3)*	590 (12.0)*	123 (2.5)†	570 (11.5)†	446 (9.0)†,‡	1510 (30.6)†	842 (17.1)†
Hispanic	326 (17.1)*	221 (12.1)*	73 (4.0)	192 (10.5)*,†	172 (9.4)‡	421 (23.1)*	421 (23.1)

/Latino							
White	4663 (30.3)	2025 (13.1)*	270 (1.8)*	1343 (8.7)*	1122 (7.3)*	3760 (24.4)*	2205 (14.0)*
Other	159 (21.3) *	114 (15.2)*	12 (1.6)*,†	65 (8.7)*,†	46 (6.1)*,†	247 (33.0)†	105 (14.9)*,†

Each footnote (*, †, ‡) represents a subset of race/ethnicity whose row proportion for the reason TTM was not utilized does not differ significantly from each other at the .05 level after Bonferroni correction for multiple comparisons.

DNR: Do Not Resuscitate; TTM: Targeted Temperature Management

Figure Legends:

Figure 1. Identification of Study Cohort. From a total of 457,621 patients with out-of-hospital cardiac arrest in the Cardiac Arrest Registry to Enhance Survival (CARES) from 2013-2019, we identified 96,695 patients for the final analysis.

Figure 2. Yearly Utilization of Targeted Temperature Management Stratified by Race/Ethnicity. In 60,309 patients from 375 hospitals that contributed cases over the entire course of the study, Hispanic/Latino patients received targeted temperature management less often than other races/ethnicities. After adjusting for multiple comparisons, there were no interactions between race/ethnicity and time.