ORIGINAL ARTICLE

Community and EMS Interventions to Improve Survival in Cardiac Arrest

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ABSTRACT

BACKGROUND

Early cardiopulmonary resuscitation (CPR) and defibrillation improve survival after out-of-hospital cardiac arrest, but evidence from randomized trials about whether community-based implementation strategies improve outcomes is lacking.

METHODS

We conducted a registry-based, cluster-randomized trial involving adults with out-of-hospital cardiac arrest treated by emergency medical services (EMS) in North Carolina counties. The counties were grouped into clusters, which were then randomly assigned in a 1:1 ratio to implement a multifaceted intervention or administer usual care. The intervention included four components: training of 911 telecommunicators to improve rapid recognition of cardiac arrest, training of 911 telecommunicators to improve delivery of CPR instructions from telecommunicators to bystanders, community CPR training, and enhanced use of automated external defibrillators by first responders or bystanders before EMS arrival. Data were collected through the Cardiac Arrest Registry to Enhance Survival. The primary outcome was survival to hospital discharge with a good neurologic outcome (Cerebral Performance Category score of 1 or 2; range, 1 to 5, with higher scores indicating worse neurologic outcome).

RESULTS

From July 1, 2022, to June 30, 2026, a total of 28 clusters comprising 11,615 patients were assigned to the intervention group, and 27 clusters comprising 10,844 patients were assigned to the usual-care group. The median age of the patients was 64.0 years, and 36.7% were women. The percentage of patients who survived to hospital discharge with a good neurologic outcome was 9.0% (1048 of 11,608 patients) in the intervention group and 9.4% (1017 of 10,839 patients) in the usual-care group (adjusted odds ratio, 0.97; 95% confidence interval, 0.75 to 1.26; P=0.80).

CONCLUSIONS

Among adults with out-of-hospital cardiac arrest, implementation of a multifaceted strategy involving the community and EMS did not result in a greater percentage of patients who survived to hospital discharge with a favorable neurologic outcome than usual care. (Funded by the National Heart, Lung, and Blood Institute of the National Institutes of Health; RACE-CARS ClinicalTrials.gov number, NCT04660526.)

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*A complete list of the RACE-CARS trial investigators is available in the Supplementary Appendix, available at NEJM.org.

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Out-of-hospital cardiac arrest affects approximately 350,000 adults treated by emergency medical services (EMS) in the United States annually, and less than 10% survive with a favorable neurologic outcome.[1-4] Survival after cardiac arrest depends on the rapid delivery of time-sensitive interventions, including recognition of cardiac arrest, activation of EMS, initiation of cardiopulmonary resuscitation (CPR), and defibrillation.[1,5-7] These interventions require a coordinated response that involves bystanders, 911 telecommunicators, first responders, and EMS workers. Delays at any step may substantially reduce the likelihood of neurologically intact survival.[8,9]

Communities have implemented strategies to improve individual components of this response, including widespread CPR training,[10-12] dispatcher-assisted CPR,[13] public-access defibrillation,[14] first-responder programs,[7,15,16] and improvements in EMS care.[17] In a study conducted in North Carolina, combined interventions were associated with increased frequencies of CPR performed by bystanders and defibrillation performed by first responders and improved survival.[15] However, the study was observational and included only 11 counties, which limited causal inference. Other studies supporting bundled community interventions have also been predominantly observational.[10,12,18] The 2025 American Heart Association guidelines consider implementation of bundled community initiatives reasonable for improving lay-rescuer response to out-of-hospital cardiac arrest.[8] However, evidence from randomized trials evaluating whether a coordinated system of care for cardiac arrest improves clinical outcomes is lacking.[8] The Randomized Cluster Evaluation of Cardiac Arrest Systems (RACE-CARS) trial[19] was conducted to determine whether a multifaceted, customized set of interventions aimed at emergency dispatch, the community, and first responders would improve the frequency of resuscitation and increase survival to hospital discharge with a favorable neurologic outcome among patients with out-of-hospital cardiac arrest.

METHODS

TRIAL DESIGN AND OVERSIGHT

RACE-CARS was a registry-based, cluster-randomized trial conducted in North Carolina.[19] Counties participating in the trial were grouped into clusters according to local EMS-system governance. The participating counties included rural and urban communities and had a combined population of approximately 8.5 million persons. After a 12-month training-and-implementation period, the intervention was evaluated with the use of data collected from July 1, 2022, to June 30, 2026. Consecutive patients with out-of-hospital cardiac arrests were identified through the Cardiac Arrest Registry to Enhance Survival (CARES),[4] which uses standardized definitions and quality-assurance procedures for surveillance of out-of-hospital cardiac arrests.

The protocol and trial design have been described previously[19] and are available with the full text of this article at NEJM.org. The trial was funded by the National Heart, Lung, and Blood Institute (NHLBI). The institutional review board at Duke University approved the trial and waived the need for individual patient consent. An independent data and safety monitoring board appointed by the NHLBI oversaw trial conduct. Trial oversight and author responsibilities are provided in the Supplementary Appendix, which is available at NEJM.org.

TRIAL POPULATION

Adults 18 years of age or older in participating counties who had an out-of-hospital cardiac arrest resulting from a nontraumatic cause and underwent attempted resuscitation were identified consecutively through CARES. Patient eligibility was determined according to prespecified CARES criteria. Patients with cardiac arrests resulting from traumatic causes and those with cardiac arrests managed by non–911 EMS transport providers were not included. Patients with cardiac arrests witnessed by EMS or occurring in nursing homes or health care facilities were also not eligible for inclusion. Complete eligibility criteria are provided in Table S1 in the Supplementary Appendix.

RANDOMIZATION

Clusters were randomly assigned in a 1:1 ratio to implement the intervention or to administer usual care. Randomization was performed with a covariate-constrained randomization method and was stratified according to eight prespecified cluster characteristics: population size, rural or urban location, proportion of Black residents, proportion of Hispanic residents, median household income, baseline frequency of bystander

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CPR, baseline frequency of defibrillation before EMS arrival, and baseline proportion of patients who survive to hospital discharge after out-of-hospital cardiac arrest.[20]

TRIAL INTERVENTION

The intervention had four components: training of 911 telecommunicators to improve rapid recognition of cardiac arrest with priority dispatch of EMS and first responders (component 1); training of 911 telecommunicators to improve systematic and rapid delivery of dispatcher-assisted CPR instructions to bystanders (component 2); comprehensive community training of lay persons in hands-only CPR and use of an automated external defibrillator, targeting 10% of the population (component 3); and enhanced response of first responders and bystanders, including use of CPR and defibrillators before EMS arrival (component 4). Implementation began in the year before the 4-year assessment period and continued throughout the trial. Each component is described in the manual of operations (see the Supplementary Appendix). Clusters assigned to usual care continued administering usual care without restrictions.[19]

For the assessment of implementation and fidelity, the four components were grouped into three domains: 911 telecommunicator quality improvement (components 1 and 2), community CPR and defibrillator training (component 3), and first-responder engagement (component 4). The plan for implementing the four components was tailored to each county. Under the direction of the coordinating center, each county developed an implementation plan for each domain and updated the plan annually on the basis of the most recent CARES performance data, local barriers, and available resources. Plans were developed collaboratively by local EMS leadership; emergency dispatch centers; fire and law-enforcement agencies; colleges and universities; community organizations, such as churches and school systems; local American Heart Association affiliates; American Red Cross chapters; and the trial intervention team.[19] Counties were supported by the following standardized implementation strategies: the manual of operations; monthly telephone conference calls with EMS personnel, first responders, and 911 center personnel; county team meetings conducted at least twice each year; annual statewide meetings; and regular written feedback with standardized reports on local performance as compared with other intervention counties. Defibrillators were donated by several manufacturers (see the Supplementary Appendix) to counties in the intervention clusters for equipping first responders and for distribution in publicly accessible locations when possible. County leads (EMS personnel who served as primary contacts for the trial) completed implementation surveys every 6 months, which the coordinating center reviewed. Fidelity to the intervention[21] was measured as the percentage of specified intervention activities implemented by each county within each of the three domains. Further details are provided in the Supplementary Appendix.

OUTCOMES

The primary outcome was survival to hospital discharge with a favorable neurologic outcome, defined as a Cerebral Performance Category score of 1 or 2 (range, 1 to 5, with higher scores indicating worse neurologic outcome).[22] Prespecified secondary outcomes were CPR performed by a bystander and defibrillation performed by a bystander or a first responder before EMS arrival. Prespecified tertiary and ancillary outcomes included 911 telecommunicator recognition of cardiac arrest and dispatcher-assisted CPR. Additional tertiary outcomes were survival to hospital discharge, modified Rankin score at 3 and 12 months, and quality of life as assessed with the 36-Item Short Form Survey and EuroQol Group 5-Dimension 5-Level instruments at 3 and 12 months among survivors; these results are not reported here.

DATA COLLECTION

Consecutive patients with eligible out-of-hospital cardiac arrests were identified through CARES. Participating EMS agencies, 911 centers, and hospitals entered standardized clinical and outcome data according to Utstein reporting guidelines and definitions (standardized definitions and templates for reporting out-of-hospital cardiac arrests).[23] The standardized CARES data elements were used for the primary analysis.[4]

STATISTICAL ANALYSIS

The trial was designed to enroll approximately 20,000 patients across 50 clusters and had 85% power, at a two-sided type I error rate of 0.05, to detect an increase in survival with a good neurologic outcome from 9% in the usual-care group to

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12% in the intervention group, accounting for within-cluster correlation (assuming an intracluster correlation coefficient of 0.01).[19] The primary analysis was performed in accordance with the intention-to-treat principle and included all eligible patients in participating, randomized clusters. The primary and secondary outcomes were analyzed by means of logistic regression with generalized estimating equations to account for within-cluster correlation, with an exchangeable working correlation structure. The prespecified primary model was adjusted for age, sex, race, Hispanic ethnic group, location type during cardiac arrest, arrest-witness status, response time (defined as the lower of time to EMS arrival and time to first-responder arrival if both were available), and initial cardiac rhythm.

Intervention effects are reported as adjusted odds ratios with 95% confidence intervals. An odds ratio greater than 1.0 indicates higher odds of the outcome occurring with the intervention than with usual care. Prespecified subgroup analyses assessed the consistency of the intervention effect across key baseline characteristics. In a sensitivity analysis, patients with missing primary-outcome data were classified as not having met the criteria for the outcome. A mixed-effects logistic-regression model with a random intercept for cluster was used as an additional sensitivity analysis. Missing data for model covariates were imputed to the median for continuous variables and to the most frequent category for categorical variables. Response time was Winsorized to the 99th percentile to handle extreme values.

Two interim efficacy analyses[24,25] were conducted in July 2024 and July 2025. A conservative Haybittle–Peto boundary ($P \leq 0.001$) was used for consideration of early termination for efficacy. All tests were two-sided, with a nominal significance level of 0.05. The widths of the confidence intervals have not been adjusted for multiplicity and should not be used to infer an effect of the intervention. Statistical analyses were conducted with SAS software, version 9.4 or later (SAS Institute).

RESULTS

CLUSTERS AND PATIENTS

A total of 57 clusters, which included 62 participating counties, underwent randomization; 2 clusters that underwent randomization (1 assigned to the intervention group and 1 to the usual-care group), representing 2 counties, declined to participate. Therefore, the analytic dataset is based on 55 clusters (28 in the intervention group and 27 in the usual-care group), representing 60 counties in North Carolina (Fig. S1). The resulting intervention and usual-care groups appeared to be well balanced across the prespecified cluster characteristics (Table S2).

During the 4-year assessment period, 33,570 out-of-hospital cardiac arrests were identified through CARES. A total of 22,459 patients met the inclusion criteria and were included in the primary analysis, and all but 12 (0.05%) underwent primary-outcome assessment (Fig. 1). Baseline characteristics of the patients seemed to be well balanced among the clusters; the median age of the patients was 64.0 years (interquartile range, 51.0 to 74.0), 36.7% were women, 33.3% were Black, 3.9% were Hispanic or Latino, and 28.5% lived in rural areas (Table 1 and Tables S3 and S4).

INTERVENTION IMPLEMENTATION

Clusters in the intervention group implemented the intervention components with varying fidelity and reach (see the Supplementary Appendix). All 911 centers in the intervention clusters implemented the CARES dispatch module, which involved collecting and reviewing metrics such as the proportion of cardiac arrests recognized, the proportion of cardiac arrests managed with successful dispatcher-assisted CPR, and the time from receipt of the 911 call until initiation of CPR. The mean fidelity to the intervention for the 911 telecommunicator quality-improvement domain was 90.5% (range, 50.0 to 100.0), whereas the mean fidelity for the first-responder engagement domain and the community CPR and defibrillator training domain was 77.6% (range, 45.0 to 100.0) and 52.0% (range, 20.0 to 80.0), respectively. Organization of community partners, such as universities, to facilitate community CPR training was the most consistently implemented item of the intervention components (implemented in 85.3% of the county survey periods), whereas training events for underrepresented populations were implemented in 56.6% of the survey periods, training of all employees at local workplaces was implemented in 54.4%, public awareness campaigns were implemented in 34.2%, and partnerships with county leadership were implemented in 31.2%.

Community partners reported 5724 CPR train-

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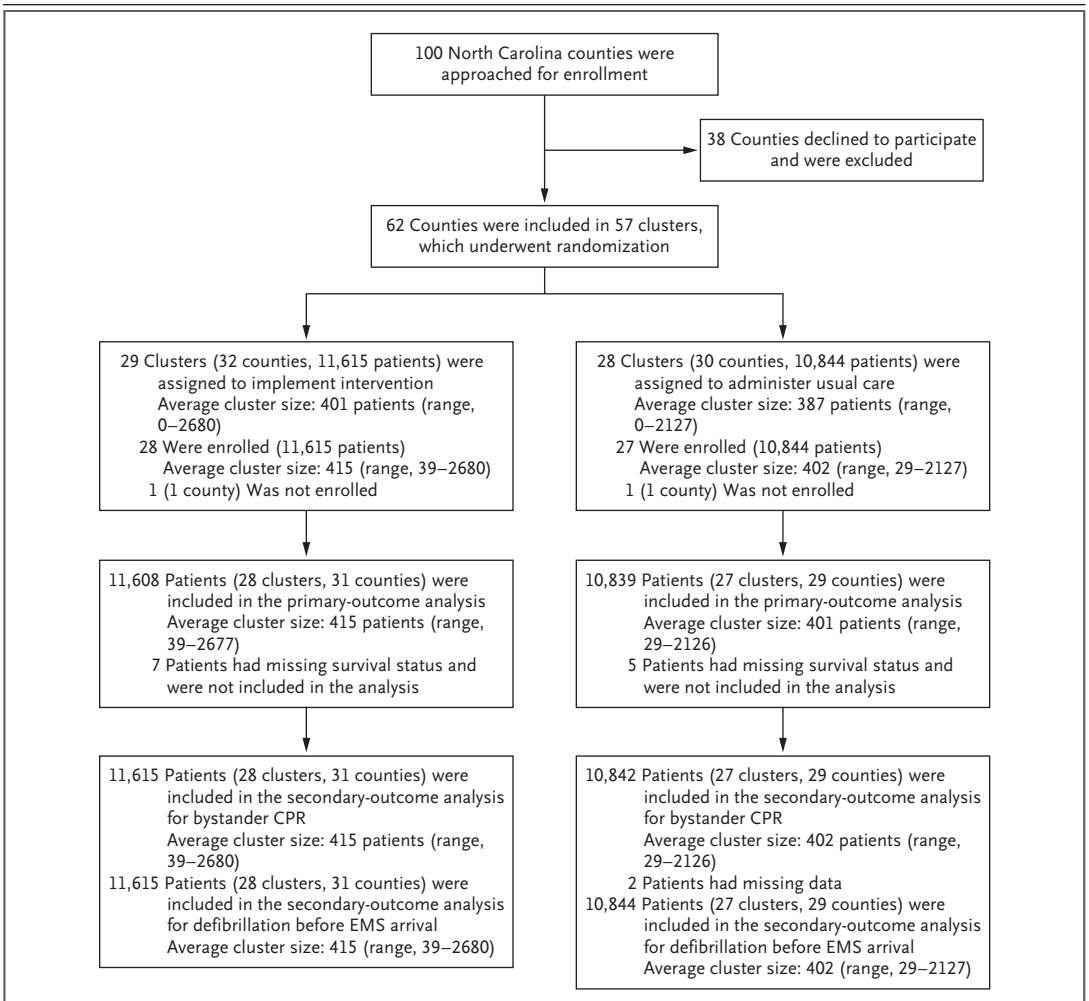


Figure 1. Randomization and Outcomes.
CPR denotes cardiopulmonary resuscitation.

ing events that reached 201,586 persons (4.8% of the population in the intervention counties; county median, 4.1%; range, 0.2 to 29.5). Cumulative training was administered to 2.3% of the population in the intervention counties in year 2, to 3.6% in year 3, and to 4.8% in year 4. Four counties trained more than 10% of their population and 8 trained less than 3%. In the intervention clusters, 30 counties received a total of 405 defibrillators, and 4 of these counties did not deploy the defibrillators; of the 26 counties that did deploy the devices, 19 placed defibrillators in publicly accessible locations and 18 deployed defibrillators with first responders, including those in fire departments and law-enforcement agencies.

PRIMARY OUTCOME

The percentage of patients who survived to hospital discharge with a favorable neurologic outcome was 9.0% (1048 of 11,608 patients) in the intervention group and 9.4% (1017 of 10,839 patients) in the usual-care group (adjusted odds ratio, 0.97; 95% confidence interval [CI], 0.75 to 1.26; P=0.80) (Table 2). Results appeared to be consistent over time and across subgroups (Fig. 2 and Figs. S2 and S3), including subgroups defined according to initial rhythm, arrest-witness status, regional classification, and location of arrest. A sensitivity analysis conducted with a mixed-effects model with random intercept (random at the cluster level) to account for between-cluster vari-

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Table 1. Demographic and Cardiac-Arrest Characteristics of the Patients at Baseline.*

Characteristic	Intervention (N=11,615)	Usual Care (N=10,844)	Total (N=22,459)
Demographic			
Median age (IQR) — yr	64.0 (50.0–74.0)	64.0 (52.0–75.0)	64.0 (51.0–74.0)
Female sex — no./total no. (%)	4297/11,614 (37.0)	3952/10,844 (36.4)	8249/22,458 (36.7)
Race or ethnic group — no./total no. (%)†			
Asian	139/11,402 (1.2)	158/10,772 (1.5)	297/22,174 (1.3)
Black	3857/11,402 (33.8)	3517/10,772 (32.6)	7374/22,174 (33.3)
White	6762/11,402 (59.3)	6661/10,772 (61.8)	13,423/22,174 (60.5)
Hispanic or Latino	447/11,402 (3.9)	419/10,772 (3.9)	866/22,174 (3.9)
Cardiac Arrest			
Arrest location — no./total no. (%)			
Private	9926/11,615 (85.5)	9225/10,844 (85.1)	19,151/22,459 (85.3)
Public	1689/11,615 (14.5)	1619/10,844 (14.9)	3308/22,459 (14.7)
First monitored rhythm — no./total no. (%)‡			
Nonshockable	9044/11,614 (77.9)	8149/10,844 (75.1)	17,193/22,458 (76.6)
Shockable	2570/11,614 (22.1)	2695/10,844 (24.9)	5265/22,458 (23.4)
Arrest-witness status — no./total no. (%)			
Witnessed by bystander	5778/11,615 (49.7)	5547/10,844 (51.2)	11,325/22,459 (50.4)
Unwitnessed	5837/11,615 (50.3)	5297/10,844 (48.8)	11,134/22,459 (49.6)
First to apply AED — no./total no. (%)			
Bystander	230/11,613 (2.0)	223/10,843 (2.1)	453/22,456 (2.0)
First responder not providing transportation	5987/11,613 (51.6)	5564/10,843 (51.3)	11,551/22,456 (51.4)
Responding EMS personnel	5396/11,613 (46.5)	5056/10,843 (46.6)	10,452/22,456 (46.5)
Sustained ROSC — no./total no. (%)	3133/11,615 (27.0)	3213/10,844 (29.6)	6346/22,459 (28.3)
Median response time (IQR) — min§	8.8 (6.5–11.7)	7.3 (5.4–10.1)	8.0 (5.9–11.0)

* AED denotes automated external defibrillator, EMS emergency medical services, IQR interquartile range, and ROSC return of spontaneous circulation.
† Race and ethnic group were determined by EMS personnel at the time of the cardiac-arrest event.
‡ Some cases presented as nonshockable and then converted to shockable.
§ Response time is the time from the 911 call to the arrival of the first responder or EMS.

ability showed an odds ratio of 1.03 (95% CI, 0.80 to 1.34).

SECONDARY OUTCOMES

CPR was performed by a bystander in 5205 of 11,615 patients (44.8%) in the intervention group and in 4591 of 10,842 patients (42.3%) in the usual-care group (adjusted odds ratio, 1.06; 95% CI, 0.87 to 1.29). Defibrillation was performed before EMS arrival in 1567 of 11,615 patients (13.5%) in the intervention group and in 1658 of 10,844 patients (15.3%) in the usual-care group (adjusted odds ratio, 0.79; 95% CI, 0.42 to 1.49).

TERTIARY OUTCOMES

A 911 telecommunicator recognized the need for CPR in 6659 of 7923 patients in the intervention group (84.0%); among these patients, CPR was initiated within 90 seconds after the recognition of the need for CPR in 2962 of 5829 patients (50.8%). CPR instructions were given by 911 telecommunicators for 5502 of 7842 patients (70.2%).

ADDITIONAL ANALYSES

The adjusted odds ratio for bystander CPR in year 4 was 1.33 (95% CI, 1.02 to 1.75) (Fig. 3).

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Table 2. Primary and Secondary Outcomes.*

Outcome	Intervention (N=11,615)	Usual Care (N=10,844)	Odds Ratio (95% CI)†	Adjusted Odds Ratio (95% CI)†‡
	no. of patients/total no. (%)			
Primary outcome				
Survival to hospital discharge with good neurologic outcome§	1048/11,608 (9.0)	1017/10,839 (9.4)	0.96 (0.74–1.23)¶	0.97 (0.75–1.26)‖
Secondary outcomes				
CPR performed by bystander	5205/11,615 (44.8)	4591/10,842 (42.3)	1.04 (0.86–1.26)	1.06 (0.87–1.29)
Defibrillation performed by bystander or first responder before EMS arrival	1567/11,615 (13.5)	1658/10,844 (15.3)	0.84 (0.63–1.12)	0.79 (0.42–1.49)

* CPC denotes Cerebral Performance Category, and CPR cardiopulmonary resuscitation.
† Both unadjusted and adjusted analyses used methods that accounted for within-cluster correlation of outcomes among cases of out-of-hospital cardiac arrest within randomized clusters using a generalized estimating equation framework. For secondary outcomes, the widths of the confidence intervals have not been adjusted for multiplicity and should not be used to infer intervention effect.
‡ The odds ratio was adjusted for confounders specified a priori, including age (spline knot at 65 years), sex (reference, male sex), ethnic group (reference, non-Hispanic or non-Latino), race (reference, White), location (reference, private), arrest-witness status (reference, unwitnessed), response time, and initial rhythm (reference, nonshockable).
§ A good neurologic outcome was defined as a CPC score of 1 or 2 (range, 1 to 5, with higher scores indicating worse neurologic outcome).
¶ P=0.74.
‖ P=0.80.

The results over time with respect to defibrillation before EMS arrival are also shown in Figure 3.

DISCUSSION

The primary finding of this randomized, controlled trial is that implementation of a four-component customized intervention involving the community and EMS did not result in a higher percentage of patients who survived to hospital discharge with a favorable neurologic outcome, underwent CPR performed by a bystander, or underwent defibrillation before EMS arrival than administration of usual care. The trial assessed the effect of a multifaceted strategy as implemented across heterogeneous communities rather than the efficacy of each intervention component under uniform implementation. We could not determine whether the lack of improvement resulted from a lack of effect of the intervention components, insufficient implementation intensity, contextual barriers, or a combination of these factors. The lack of an effect on survival is consistent with the lack of corresponding overall improvements in the intermediate outcomes of bystander CPR and early defibrillation. The increase in the percentage of patients who underwent CPR performed by a bystander in year 4, as seen in the exploratory analysis, suggests that the components of the intervention involving bystander CPR appear to have been effective and that a longer period may be needed to identify important improvements and determine whether these components have an effect on survival. Taken together, the findings have important implications regarding the design and conduct of future studies to address persistently low survival among patients with out-of-hospital cardiac arrest.

The trial, which covered a population of more than 8 million people, was pragmatic. Clusters underwent randomization with covariate adjustment to provide balance in baseline features. All eligible patients with cardiac arrest were included owing to a waiver of individual patient consent, and therefore the trial is not only representative but also inclusive of the population studied. Baseline and follow-up data were efficiently collected as part of the existing CARES registry, and follow-up was nearly 100% complete with respect to the primary and secondary outcomes.

Several implementation-related factors may explain the lack of improvements in outcomes. Fidelity was high for the 911 telecommunicator domain and moderate for the first-responder engagement domain but low for the community training domain, especially for large-scale goals such as training all employees within workplaces, training in underserved communities, or conduct-

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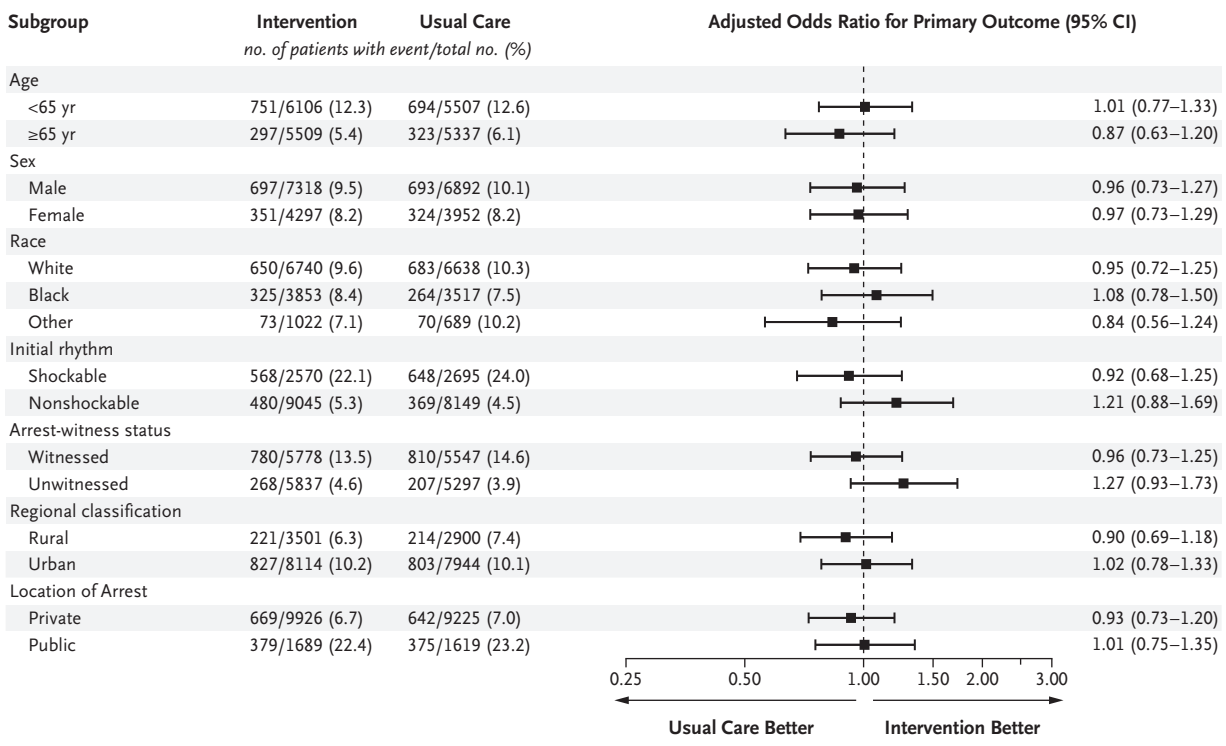


Figure 2. Analysis of the Primary Outcome in Subgroups.

Shown are the percentages of patients in prespecified subgroups who were alive and had a good neurologic outcome at hospital discharge (the primary outcome). The adjusted model uses methods that account for within-cluster correlation of outcomes among patients with out-of-hospital cardiac arrest within randomized clusters with the use of a generalized estimating equation framework. The forest plot is based on the imputed dataset used for the subgroup analyses, where missing values were imputed with the use of the median for continuous variables and the mode for categorical variables. Consequently, denominators for some subgroups may differ between the tables and the forest plot. In addition to adjustment for subgroup and interaction term, the odds ratio was adjusted for confounders specified a priori, including age (spline knot at 65 years), sex (reference, male sex), ethnic group (reference, non-Hispanic or non-Latino), race (reference, White), arrest location type (reference, private), arrest-witness status (reference, unwitnessed), response time, and initial rhythm (reference, nonshockable). Race was determined by emergency medical services personnel at the time of the cardiac-arrest event.

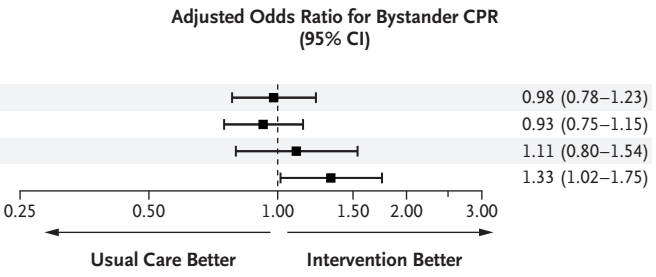
ing public-awareness campaigns. The trial tested the intervention as counties were able to implement it; therefore, shortages in resources, staff, and organizational capacity may explain the less frequent implementation of these items of the community training domain. Cumulative CPR training across intervention clusters reached 4.8% of the population, and eight counties trained less than 3% of their population. Training at this level, with uneven distribution, may have been insufficient to shift bystander CPR in the overall population during the 4 years. Nonetheless, the trial achieved hands-only CPR training of more than 200,000 people, with reach into rural counties in North Carolina. Although the 10% target was set as a pragmatic goal intended to drive substantial expansion of training, the level required to change outcomes is unknown. However, the apparent increase in bystander CPR in year 4 of the trial suggests that training approximately 5% of the population may have had an effect, and longer and more intense efforts may be needed and should be tested in future trials.[11,26,27]

Challenges also affected the 911 telecommunicator domain. Participating 911 centers developed locally tailored strategies to improve cardiac-arrest recognition and time to initiation of dispatcher-assisted CPR. Protocol constraints, staff turnover, and unmeasured variability in implementation may have limited changes in performance. Improving telecommunicator recognition and CPR

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A Bystander CPR

Trial Year	Intervention	Usual Care
	no. of patients with event/total no. (%)	
Trial year 1	1218/3113 (39.1)	1119/2917 (38.4)
Trial year 2	1244/2940 (42.3)	1162/2652 (43.8)
Trial year 3	1367/2873 (47.6)	1198/2681 (44.7)
Trial year 4	1376/2689 (51.2)	1112/2592 (42.9)



B Cardiac Arrest Defibrillated before EMS Arrival

Trial Year	Intervention	Usual Care
	no. of patients with event/total no. (%)	
Trial year 1	368/3113 (11.8)	385/2919 (13.2)
Trial year 2	378/2940 (12.9)	394/2652 (14.9)
Trial year 3	401/2873 (14.0)	439/2681 (16.4)
Trial year 4	420/2689 (15.6)	440/2592 (17.0)

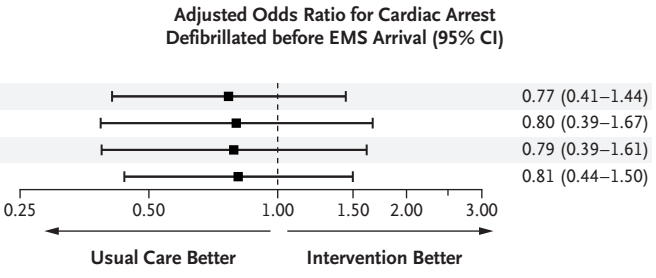


Figure 3. Analyses of the Secondary Outcomes According to Trial Year.

Shown are the percentages of patients who received CPR from a bystander (Panel A) and who underwent defibrillation performed by a bystander or first responder before the arrival of emergency medical services (EMS) (Panel B), both of which are secondary outcomes. In adjusted analyses, a generalized estimating equation framework was used to account for within-cluster correlation of outcomes among patients. Odds ratios were adjusted for confounders specified a priori, including age (spline knot at 65 years), sex (reference, male sex), ethnic group (reference, non-Hispanic or non-Latino), race (reference, White), location type (reference, private), arrest-witness status (reference, unwitnessed), response time, and initial rhythm (reference, nonshockable). The widths of the confidence intervals have not been adjusted for multiplicity and should not be used to infer intervention effect.

instruction at scale may warrant more intensive implementation strategies.

Efforts to include community leaders, such as county commissioners and church leaders, were intended to promote sustainable and broad changes in behavior. This approach, however, was gradual and variable across counties. Although engaging volunteer fire departments and law-enforcement agencies to respond to all cardiac arrests and carry defibrillators was a goal, redirecting local resources to achieve this goal was also gradual and variable across counties. Approaches that expand responder availability, including off-duty-responder models, may warrant evaluation.

These findings underscore the difficulty of producing community-wide changes[28] in the early response to cardiac arrest.[29] Timely recognition of cardiac arrest and activation of EMS are prerequisites for interventions to occur early enough to influence outcome. Some previous observational studies, including one conducted in North Carolina,[15] have shown that interventions aimed at improving responses of bystanders and first responders are associated with an increased frequency of bystander and first-responder intervention[10,11,18,26] and improved survival,[15,16,26] whereas others have not shown this result.[29] This inconsistency highlights the need for randomized, controlled trials to reliably assess the effect of interventions. Even though our trial included more than 22,000 patients, the confidence intervals around the estimate of no effect include the possibility of modest benefit or harm.

Limitations of our trial include challenges regarding implementation within 911 centers, particularly in the context of staffing constraints and turnover and operational pressures related to the coronavirus disease 2019 pandemic and Hurricane Helene that affected counties in western North Carolina. Moreover, complete dispatch data could not be obtained from several counties in the intervention clusters, which limited our ability to determine the extent to which the intended

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changes in telecommunicator performance were implemented. First-responder response times were not consistently reported in the intervention clusters, which limited our ability to assess changes and intervention effects according to response times. Intervention activities were not measured in the usual-care counties. Data on the fidelity to the intervention were based on report by county leads. Higher baseline performance in some communities may have reduced the incremental improvement that was achievable during the trial. However, meaningful gaps remained in the occurrence of bystander CPR, early defibrillation, cardiac-arrest recognition, and rapid telecommunicator-assisted CPR, making a uniform ceiling effect unlikely.

In this cluster-randomized trial, implementation of a multifaceted strategy involving the community and EMS did not result in a greater percentage of patients who survived to hospital discharge with a favorable neurologic outcome among patients with out-of-hospital cardiac arrest.

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