

# **Supplemental Material**

## **Appendix**

### **Adult Resuscitation Task Force Members:**

Anne Grossestreuer PhD; Ari Moskowitz MD; Dana Edelson MD MS; Joseph Ornato MD; Katherine Berg MD; Mary Ann Peberdy MD; Matthew Churpek MD MPH PhD; Michael Kurz MD MS-HES; Monique Anderson Starks MD MHS; Paul Chan MD MSc; Saket Girotra MBBS SM; Sarah Perman MD MSCE; Zachary Goldberger MD MS

## Data S1.

### Supplemental Methods and Results

#### Data Filtering

Sample size

	<b>Step</b>	<b>N.events</b>	<b>N.admissions</b>	<b>N.eCPR</b>
	Raw data	359107	300649	1303
	Exclude all admissions with OOH_ARREST==1	344837	289833	1250
	Excluding events occurred more than 4 hrs before admission	344667	289726	1250
	Excluding events occurred prior to admission (EVT_DT < ADM_DT) if ADM_DTM is missing	344653	289714	1250
	Excluding events with SUBJ_TY=7 (visitors..)	344159	289248	1250
	Excluding events with ILL_CAT=8 (visitors..)	344007	289248	1249
	Excluding events from hospitals that could not be matched to the hospital data	343870	288998	1249
	Removing all events from non-eCPR hospitals	218823	182764	1249
	Removing all events before the first eCPR of the hospital	156547	130035	1249
	Keeping only the first event per admission	130035	130035	1098
	Remove patients with admission CPC =Brain death	129963	129963	1097
	Remove additional hospitals with no eCPR patients left	128809	128809	1097
	Excluding hospitals with <5 events or duration for provided events shorter than 6 months	128619	128619	1082

**Table S1. Descriptive summary of hospital characteristics at hospital level.**

<b>Variable*</b>	<b>Summary (N=219)</b>
Hospital Beds	
<i>1-100</i>	3 (1.4%)
<i>101-199</i>	16 (7.4%)
<i>201-249</i>	13 (6%)
<i>251-299</i>	26 (12%)
<i>301-349</i>	21 (9.7%)
<i>351-499</i>	57 (26.4%)
<i>≥500</i>	80 (37%)
Annual Admissions	
<i>100-2,499</i>	2 (0.9%)
<i>2,500-4,999</i>	4 (1.9%)
<i>5,000-7,499</i>	8 (3.7%)
<i>7,500-9,999</i>	6 (2.8%)
<i>10,000-14,999</i>	40 (18.5%)
<i>15,000-19,999</i>	49 (22.7%)
<i>20,000-29,999</i>	54 (25%)
<i>30,000-39,999</i>	34 (15.7%)
<i>≥40,000</i>	19 (8.8%)
Cardiac ICU Beds	
<i>0</i>	43 (20.9%)
<i>1-5</i>	6 (2.9%)
<i>6-10</i>	31 (15%)
<i>11-15</i>	37 (18%)
<i>16-20</i>	32 (15.5%)
<i>21-30</i>	30 (14.6%)
<i>≥31</i>	27 (13.1%)
Cardiac ICU Beds/Total Beds (%)	
<i>0</i>	43 (20.9%)
<i>0.1 to &lt;2.5</i>	38 (18.4%)
<i>2.5 to &lt;5</i>	76 (36.9%)
<i>5 to &lt;7.5</i>	36 (17.5%)

<b>Variable*</b>	<b>Summary (N=219)</b>
7.5 to <10	7 (3.4%)
≥10	6 (2.9%)
Geographic Region of US	
<i>North / Mid Atlantic</i>	38 (17.4%)
<i>South Atlantic and Puerto Rico</i>	52 (23.9%)
<i>North Central</i>	48 (22%)
<i>South Central</i>	44 (20.2%)
<i>Mountain/Pacific</i>	36 (16.5%)
Intensive Services on site	180 (90.9%)
Urban/Rural Location	8 (3.8%)
Teaching Status	
<i>Major teaching</i>	71 (32.6%)
<i>Minor teaching</i>	121 (55.5%)
<i>Non-teaching</i>	26 (11.9%)
Medicare Days	
0	5 (2.3%)
1-1,500	7 (3.2%)
1,501-5,000	1 (0.5%)
5,001-20,000	13 (6%)
>20,000	190 (88%)

\*Number (percent, %)

Missing values: Hospital Beds=3, Annual Admissions=3, Cardiac ICU beds=13, Cardiac ICU beds/total beds (%)=13, Geographic Region of US=1, Intensive Services on site=21, Urban/Rural Location=9, Teaching Status=1, Medicare Days=3.

ICU = intensive care unit, US = United States

**Table S2. Hospital characteristics by ECPR Available and Non ECPR Available\*.**

Variable†	Non ECPR Available*	ECPR Available	P-value
	Hospital Dropped (N=594)	Hospital Kept (N=219)	
Hospital Beds			<0.001
1-100	88 (15.5%)	3 (1.4%)	-
101-199	161 (28.3%)	16 (7.4%)	-
201-249	63 (11.1%)	13 (6%)	-
251-299	50 (8.8%)	26 (12%)	-
301-349	52 (9.2%)	21 (9.7%)	-
351-499	73 (12.9%)	57 (26.4%)	-
≥500	81 (14.3%)	80 (37%)	-
Annual Admissions			<0.001
100-2,499	37 (6.5%)	2 (0.9%)	-
2,500-4,999	81 (14.3%)	4 (1.9%)	-
5,000-7,499	99 (17.4%)	8 (3.7%)	-
7,500-9,999	61 (10.7%)	6 (2.8%)	-
10,000-14,999	106 (18.7%)	40 (18.5%)	-
15,000-19,999	78 (13.7%)	49 (22.7%)	-
20,000-29,999	59 (10.4%)	54 (25%)	-
30,000-39,999	27 (4.8%)	34 (15.7%)	-
≥40,000	20 (3.5%)	19 (8.8%)	-
Cardiac ICU Beds			<0.001
0	279 (57.5%)	43 (20.9%)	-
1-5	13 (2.7%)	6 (2.9%)	-
6-10	63 (13%)	31 (15%)	-
11-15	45 (9.3%)	37 (18%)	-
16-20	30 (6.2%)	32 (15.5%)	-
21-30	35 (7.2%)	30 (14.6%)	-

Variable†	Non ECPR Available*	ECPR Available	P-value
	Hospital Dropped (N=594)	Hospital Kept (N=219)	
≥31	20 (4.1%)	27 (13.1%)	-
Cardiac ICU Beds/Total Beds (%)			<0.001
0	279 (57.5%)	43 (20.9%)	-
0.1 to <2.5	58 (12%)	38 (18.4%)	-
2.5 to <5	93 (19.2%)	76 (36.9%)	-
5 to <7.5	32 (6.6%)	36 (17.5%)	-
7.5 to <10	10 (2.1%)	7 (3.4%)	-
≥10	13 (2.7%)	6 (2.9%)	-
Geographic Region of US			0.81
North / Mid Atlantic	92 (15.9%)	38 (17.4%)	-
South Atlantic and Puerto Rico	139 (24.1%)	52 (23.9%)	-
North Central	127 (22%)	48 (22%)	-
South Central	104 (18%)	44 (20.2%)	-
Mountain/Pacific	115 (19.9%)	36 (16.5%)	-
Site in GWTG_R	594 (100%)	219 (100%)	1.00
Intensive Services on site	347 (75.8%)	180 (90.9%)	<0.001
Urban/Rural Location			<0.001
Urban	483 (87%)	202 (96.2%)	-
Rural	72 (13%)	8 (3.8%)	-
Teaching Status			<0.001
Non-teaching	192 (33.5%)	26 (11.9%)	-
Major teaching	83 (14.5%)	71 (32.6%)	-
Minor teaching	298 (52%)	121 (55.5%)	-
Medicare Days			<0.001

Variable†	Non ECPR Available*	ECPR Available	P-value
	Hospital Dropped (N=594)	Hospital Kept (N=219)	
0	33 (5.8%)	5 (2.3%)	-
1-1,500	14 (2.5%)	7 (3.2%)	-
1,501-5,000	22 (3.9%)	1 (0.5%)	-
5,001-20,000	188 (33%)	13 (6%)	-
>20,000	313 (54.9%)	190 (88%)	-

\* ECPR occurred at some “Non-ECPR available” hospitals. “Non-ECPR available” was defined for the purposes of this analysis as hospitals had done no ECPR cases, or hospitals that had submitted < 5 cardiac arrests events or <6 months of data.

† Number (%)

ECPR = extracorporeal cardiopulmonary resuscitation, CCPR = conventional cardiopulmonary resuscitation, ICU: Intensive Care Unit; GWTG-R: Get With The Guidelines—Resuscitation; US: United States

Missing values by group: Hospital Beds=26/3, Annual Admissions=26/3, Cardiac ICU beds=109/13, Cardiac ICU beds/total beds (%)=109/13, Geographic Region of US =17/1, Intensive Services on site=136/21, Urban/Rural Location=39/9, Teaching Status=21/1, Medicare Days=24/3.



**Table S3. Patient characteristics by ECPR Available vs. Non ECPR Available\* hospitals†.**

Variable‡	Non ECPR	ECPR Available	P-value§
	Available* Hospital Dropped (N=110775)	Hospital Kept (N=178223)	
Age			<0.001
<40	6270 (5.7%)	13590 (7.6%)	-
40-59	25794 (23.3%)	46325 (26%)	-
≥60	78711 (71.1%)	118308 (66.4%)	-
Male Sex	64488 (58.2%)	103102 (57.9%)	0.027
Race			<0.001
White	77230 (70.1%)	120863 (68%)	-
Black	21619 (19.6%)	40311 (22.7%)	-
Other	11281 (10.2%)	16593 (9.3%)	-
Hispanic Ethnicity	6330 (5.7%)	9623 (5.4%)	0.86
Weight(kg)	77 (63.5, 93)	78 (64.5, 95)	0.09
Pre-Existing Condition			
None	8452 (7.7%)	9547 (5.4%)	0.003
Preceding Hypoperfusion	25640 (23.2%)	49340 (27.8%)	<0.001
CVA or Neurologic Disorder	19573 (17.7%)	36387 (20.5%)	<0.001
CHF	31160 (28.2%)	51883 (29.2%)	<0.001
Diabetes Mellitus	34509 (31.2%)	57006 (32.1%)	<0.001
Hepatic Insufficiency	7687 (7%)	14067 (7.9%)	<0.001
Major Trauma	3403 (3.1%)	9015 (5.1%)	0.15
Cancer	12372 (11.2%)	21471 (12.1%)	<0.001
History of MI	15457 (14%)	27566 (15.5%)	<0.001
MI this Hospitalization	16247 (14.7%)	27793 (15.6%)	<0.001
Renal Insufficiency	36737 (33.3%)	61992 (34.9%)	<0.001
Respiratory Insufficiency	44263 (40.1%)	78969 (44.4%)	0.013

Variable‡	Non ECPR	ECPR Available	P-value§
	Available* Hospital Dropped (N=110775)	Hospital Kept (N=178223)	
<i>Sepsis</i>	18181 (16.5%)	29963 (16.9%)	<0.001
Admission CPC			<0.001
<i>CPC 1: Good cerebral performance</i>	46289 (57.1%)	82750 (59.5%)	
<i>CPC 2: Moderate cerebral disability</i>	19871 (24.5%)	30388 (21.9%)	
<i>CPC 3: Severe cerebral disability</i>	10036 (12.4%)	15698 (11.3%)	
<i>CPC 4: Coma or vegetative state</i>	4716 (5.8%)	10132 (7.3%)	
<i>CPC 5: Brain death</i>	102 (0.1%)	99 (0.1%)	

\*ECPR occurred at some “Non-ECPR capable” hospitals. “Non-ECPR capable” was defined for the purposes of this analysis as hospitals had done no ECPR cases, or hospitals that had submitted < 5 cardiac arrests events or <6 months of data.

†Exclusion criteria like keeping events after 1<sup>st</sup> ECPR, dropping brain dead patients were not applied here.

‡Number (percent, %)

§Type 3 p values from mixed effects logistic regression model, with hospitals included as a random effect.

||Median (interquartile range, IQR)

# CPC Defined as: CPC 1: Good cerebral performance, CPC 2: Moderate cerebral disability, CPC 3: Severe cerebral disability, CPC 4: Coma or vegetative state

ECPR = extracorporeal cardiopulmonary resuscitation, CCPR = conventional cardiopulmonary resuscitation, CVA = cerebrovascular accident, CHF = congestive heart failure, MI = myocardial infarction, CPC = cerebral performance category

Missing values by group: Sex=19/10, Race=645/456, Weight(kg)=50246/85640, Pre-existing condition: None=338/479, Preceding hypoperfusion=338/479, -CVA or Neurologic Disorder=338/479, -CHF=338/479, -Diabetes Mellitus=338/479, -Hepatic Insufficiency=338/479, -Major Trauma=338/479, -

Cancer =338/479, -History of MI=338/479, -MI this Hospitalization=338/479, -Renal  
Insufficiency=338/479, -Respiratory Insufficiency=338/479, -Sepsis=338/479, Admission  
CPC=29761/39156.

**Table S4. Summary of #ECPR, #CCPR, and their ratio for 23 hospitals that had eCPR cases in 2010.**

<b>Year</b>	<b>#ECPR</b>	<b>#CCPR</b>	<b>#ECPR/#CCPR ratio</b>	<b>Fraction of all ECPRs represented by these 23 hospitals</b>
2010	48	2327	0.021	1
2011	20	2872	0.007	0.645
2012	20	2607	0.008	0.357
2013	32	2675	0.012	0.36
2014	42	2663	0.016	0.368
2015	34	2608	0.013	0.296
2016	48	2717	0.018	0.425
2017	30	2506	0.012	0.288
<del>2018</del>	<del>0</del>	<del>49</del>	<del>0</del>	<del>0</del>

**Table S5. Comparing ECPR patient characteristics between two eras.**

Variable*	2000-2008 (N=357)	2009-2018 (N=725)	P -value†
Age			0.95
<40	47 (13.2%)	119 (16.4%)	-
40-59	113 (31.7%)	242 (33.4%)	-
≥60	197 (55.2%)	364 (50.2%)	-
Sex			0.24
Male	212 (59.4%)	454 (62.6%)	-
Female	145 (40.6%)	271 (37.4%)	-
Race			0.30
White	272 (76.6%)	527 (72.8%)	-
Black	42 (11.8%)	126 (17.4%)	-
Other	41 (11.5%)	71 (9.8%)	-
Hispanic Ethnicity	18 (5%)	37 (5.1%)	0.76
Weight(kg) ‡	80.0 (67.5, 95.5)	80.0 (65.6, 96.9)	0.52
Pre-existing condition			
None	16 (4.5%)	70 (9.7%)	0.39
Preceding hypoperfusion	166 (46.5%)	304 (42.1%)	0.78
CVA or Neurologic Disorder	32 (9%)	68 (9.4%)	0.42
CHF	124 (34.7%)	242 (33.5%)	0.57
Diabetes Mellitus	61 (17.1%)	185 (25.6%)	0.29
Hepatic Insufficiency	12 (3.4%)	41 (5.7%)	0.23
Major Trauma	14 (3.9%)	26 (3.6%)	0.49
Cancer	12 (3.4%)	30 (4.2%)	0.62
History of MI	99 (27.7%)	130 (18%)	0.036
MI this Hospitalization	130 (36.4%)	159 (22%)	0.16
Renal Insufficiency	55 (15.4%)	189 (26.2%)	0.001
Respiratory Insufficiency	107 (30%)	336 (46.5%)	<0.001
Sepsis	17 (4.8%)	70 (9.7%)	0.08

<b>Variable*</b>	<b>2000-2008 (N=357)</b>	<b>2009-2018 (N=725)</b>	<b>P -value†</b>
Admission CPC§			0.44
<i>CPC 1: Good cerebral performance</i>	224 (76.2%)	443 (79.1%)	-
<i>CPC 2: Moderate cerebral disability</i>	41 (13.9%)	47 (8.4%)	-
<i>CPC 3: Severe cerebral disability</i>	16 (5.4%)	23 (4.1%)	-
<i>CPC 4: Coma or vegetative state</i>	13 (4.4%)	47 (8.4%)	-
Duration between Admission and Arrest:			0.52
<24h	347 (97.2%)	697 (96.1%)	-
24 - <48h	8 (2.2%)	21 (2.9%)	-
48h - 1wk	1 (0.3%)	5 (0.7%)	-
≥1wk	1 (0.3%)	2 (0.3%)	-
Devices in place at arrest			
<i>Mechanical Ventilation</i>	205 (57.4%)	351 (48.5%)	0.27
<i>Invasive Airway</i>	197 (55.2%)	334 (46.1%)	0.38
<i>Arterial Line</i>	162 (45.4%)	316 (43.6%)	0.44
Time of Day of arrest			
7am-3pm	170 (50.4%)	330 (47.3%)	0.72
3pm-11pm	118 (35%)	240 (34.4%)	-
11pm-7am	49 (14.5%)	128 (18.3%)	-
Day of Week	53 (14.8%)	133 (18.3%)	0.16
Arrest location			0.29
<i>General inpatient  </i>	29 (8.1%)	71 (9.8%)	-
<i>Ambulatory/outpatient**</i>	7 (2%)	9 (1.2%)	-
<i>Cardiac/Coronary Unit</i>	16 (4.5%)	87 (12%)	-
<i>ICU</i>	129 (36.1%)	273 (37.7%)	-
<i>OR + procedural area + Cardiac catheterization lab</i>	163 (45.7%)	258 (35.6%)	-
<i>Emergency Department</i>	13 (3.6%)	27 (3.7%)	-
Illness Category:			0.35
<i>Medical-Noncardiac</i>	35 (9.8%)	99 (13.7%)	-

	<b>2000-2008</b>	<b>2009-2018</b>	
<b>Variable*</b>	<b>(N=357)</b>	<b>(N=725)</b>	<b>P -value†</b>
<i>Medical-Cardiac</i>	102 (28.6%)	232 (32%)	-
<i>Surgical-Cardiac</i>	190 (53.2%)	338 (46.6%)	-
<i>Surgical-Noncardiac</i>	30 (8.4%)	56 (7.7%)	-
Witnessed	346 (96.9%)	703 (97%)	0.89
Hospital resuscitation activated	143 (40.1%)	340 (46.9%)	0.58
Condition of 1st assessment			0.54
<i>Poor perfusion, lost pulses</i>	27 (7.6%)	63 (8.7%)	-
<i>Poor perfusion, never pulseless</i>	6 (1.7%)	18 (2.5%)	-
<i>Pulseless</i>	324 (90.8%)	644 (88.8%)	-
Presenting rhythm status			0.08
<i>Asystole</i>	88 (26.7%)	126 (18.6%)	-
<i>PEA</i>	106 (32.2%)	297 (43.7%)	-
<i>Pulseless Ventricular Tachycardia</i>	29 (8.8%)	64 (9.4%)	-
<i>Ventricular Fibrillation</i>	73 (22.2%)	111 (16.3%)	-
<i>Palpable pulse initially</i>	33 (10%)	81 (11.9%)	-
First Rhythm			0.62
<i>Accelerated idioventricular rhythm</i>	0 (0%)	2 (2.5%)	-
<i>Bradycardia</i>	11 (33.3%)	44 (54.3%)	-
<i>Pacemaker</i>	9 (27.3%)	7 (8.6%)	-
<i>Sinus (including sinus tachycardia)</i>	3 (9.1%)	10 (12.3%)	-
<i>Supraventricular tachyarrhythmia</i>	1 (3%)	0 (0%)	-
<i>Unknown</i>	4 (12.1%)	11 (13.6%)	-
<i>Ventricular Tachycardia with a pulse</i>	5 (15.2%)	7 (8.6%)	-
Any VF/VT	195 (54.6%)	393 (54.2%)	0.74
Number of defibrillations‡	3.0 (2.0, 6.0)	3.0 (2.0, 6.0)	0.74
Received compressions	344 (96.4%)	710 (97.9%)	0.35
Compression Method			
<i>Manual</i>	98 (92.5%)	657 (92.5%)	0.26

	<b>2000-2008</b>	<b>2009-2018</b>	
<b>Variable*</b>	<b>(N=357)</b>	<b>(N=725)</b>	<b>P -value†</b>
<i>Mechanical</i>	101 (95.3%)	97 (13.7%)	<0.001
<i>Open Cardiac Massage</i>	16 (15.1%)	138 (19.4%)	0.52
Epi boluses before pulseless‡	3.0 (1.8, 5.0)	4.0 (2.0, 6.0)	0.64
Epi boluses after pulseless‡	4.0 (2.0, 5.0)	5.0 (3.0, 9.0)	0.004
Any ROSC	257 (72.8%)	604 (83.4%)	0.12
Total duration before durable ROSC ‡	39.0 (17.2, 85.0)	35.5 (17.0, 65.0)	0.046
Induced Hypothermia	26 (11.4%)	88 (13.2%)	0.49

\* Number (percent, %)

† Type 3 p values from mixed effects logistic regression model, with hospitals included as a random effect.

‡ Median (interquartile range, IQR)

§ CPC Defined as: CPC 1: Good cerebral performance, CPC 2: Moderate cerebral disability, CPC 3: Severe cerebral disability, CPC 4: Coma or vegetative state

|| Includes adults arresting in the newborn unit

\*\* Includes rehabilitation and other

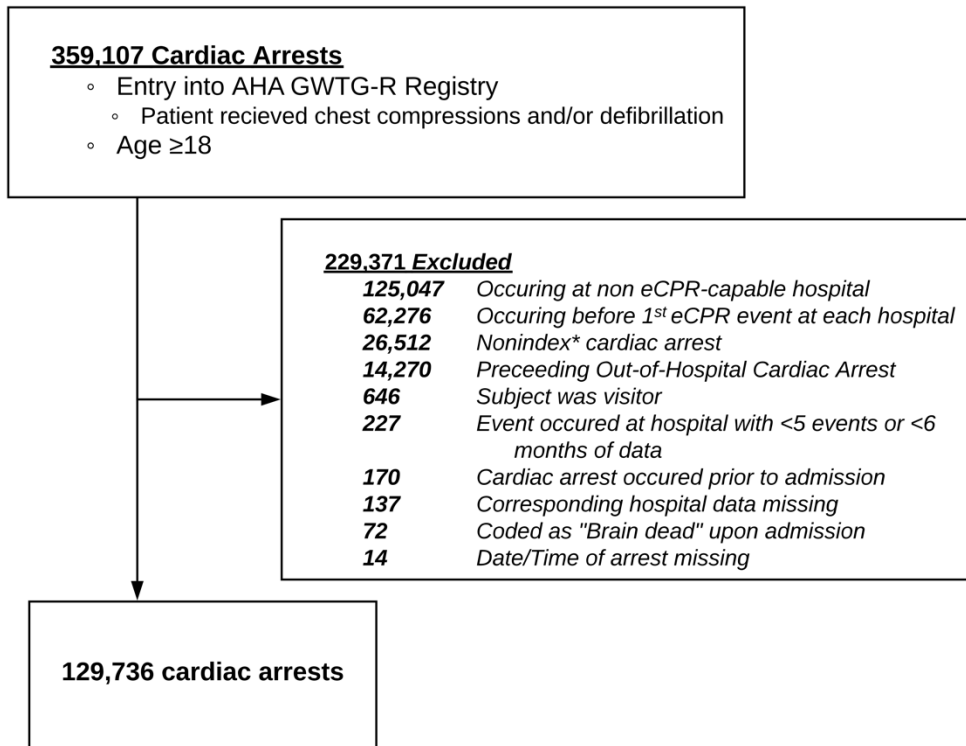
ECPR = extracorporeal cardiopulmonary resuscitation, CCPR = conventional cardiopulmonary resuscitation, CVA = cerebrovascular accident, CHF = congestive heart failure, MI = myocardial infarction, CPC = cerebral performance category, h = hours, wk = week, VF/VT = ventricular fibrillation/ventricular tachycardia, Epi = epinephrine, ROSC = return of spontaneous circulation

Missing values by group: Race=2/1, Weight(kg)=38/521, Pre-existing condition-None=0/3, -Preceding hypoperfusion=0/3, -CVA or Neurologic Disorder=0/3, -CHF=0/3, -Diabetes Mellitus=0/3, -Hepatic Insufficiency=0/3, -Major Trauma=0/3, -Cancer =0/3, -History of MI=0/3, -MI this Hospitalization=0/3, -Renal Insufficiency=0/3, -Respiratory Insufficiency=0/3, -Sepsis=0/3, Admission CPC=63/165, Devices - Mechanical Ventilation=0/1, Devices - Invasive Airway=0/1, Devices - Arterial Line=0/1, Time of Day of



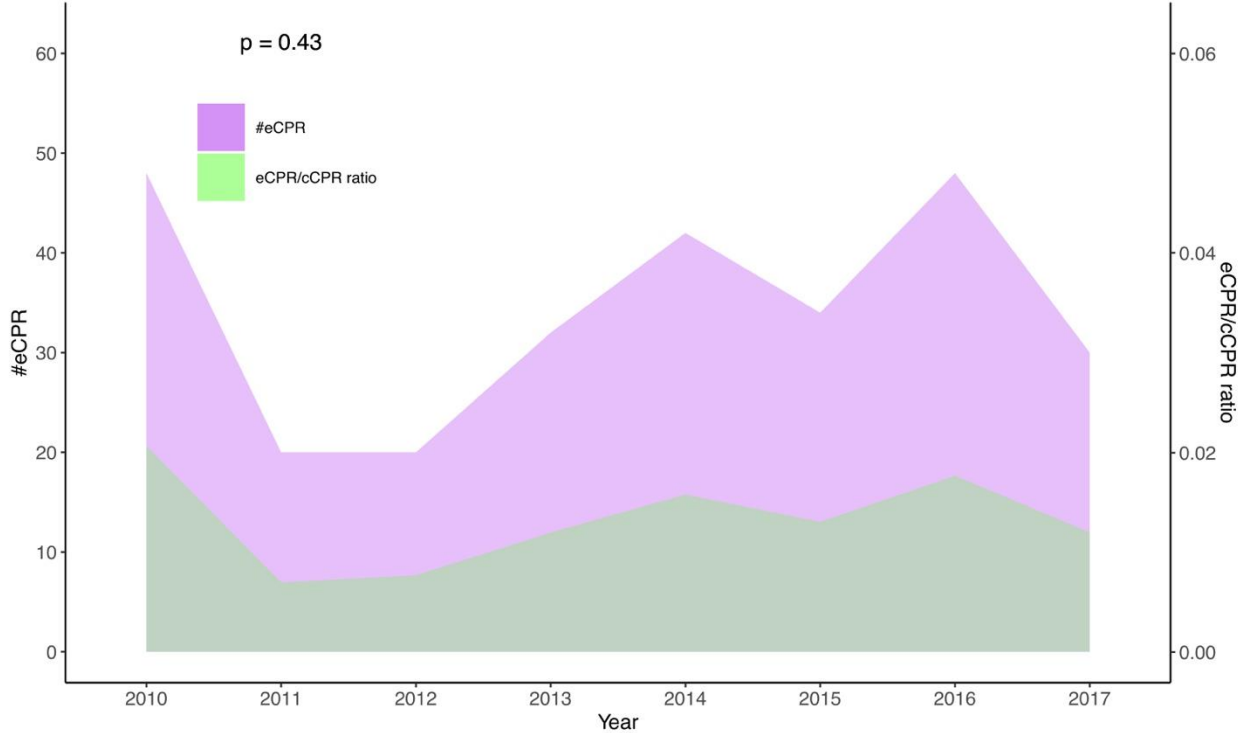
arrest=20/27, Presenting rhythm status=28/46, First Rhythm=324/644, Number of defibrillations=204/364, Compression method-Manual=251/15, Compression method-Mechanical=251/15, Compression method-Open Cardiac Massage=251/15, Epi boluses before pulseless=349/676, Epi boluses after pulseless=165/176, Any ROSC=4/1, Total duration before durable ROSC=71/91, Induced Hypothermia=128/56.

**Figure S1. Study enrollment flowchart.**



eCPR = extracorporeal cardiopulmonary resuscitation

**Figure S2. Number and percent of ECPR cases over time among hospitals that had an ECPR program in 2010.**



Data from 2018 incomplete so dropped from Figure S2. (See Table S5)

Cochran Armitage trend p value reported.

ECPR = extracorporeal cardiopulmonary resuscitation, CCPR = conventional cardiopulmonary resuscitation