WAKE COUNTY
NORTH CAROLINA

Wake EMS and SAS

Public/Private Partnership to Improve Cardiac Arrest Care

Public Health Announcement

In wine there is wisdom

In beer there is strength

In water there are bacteria

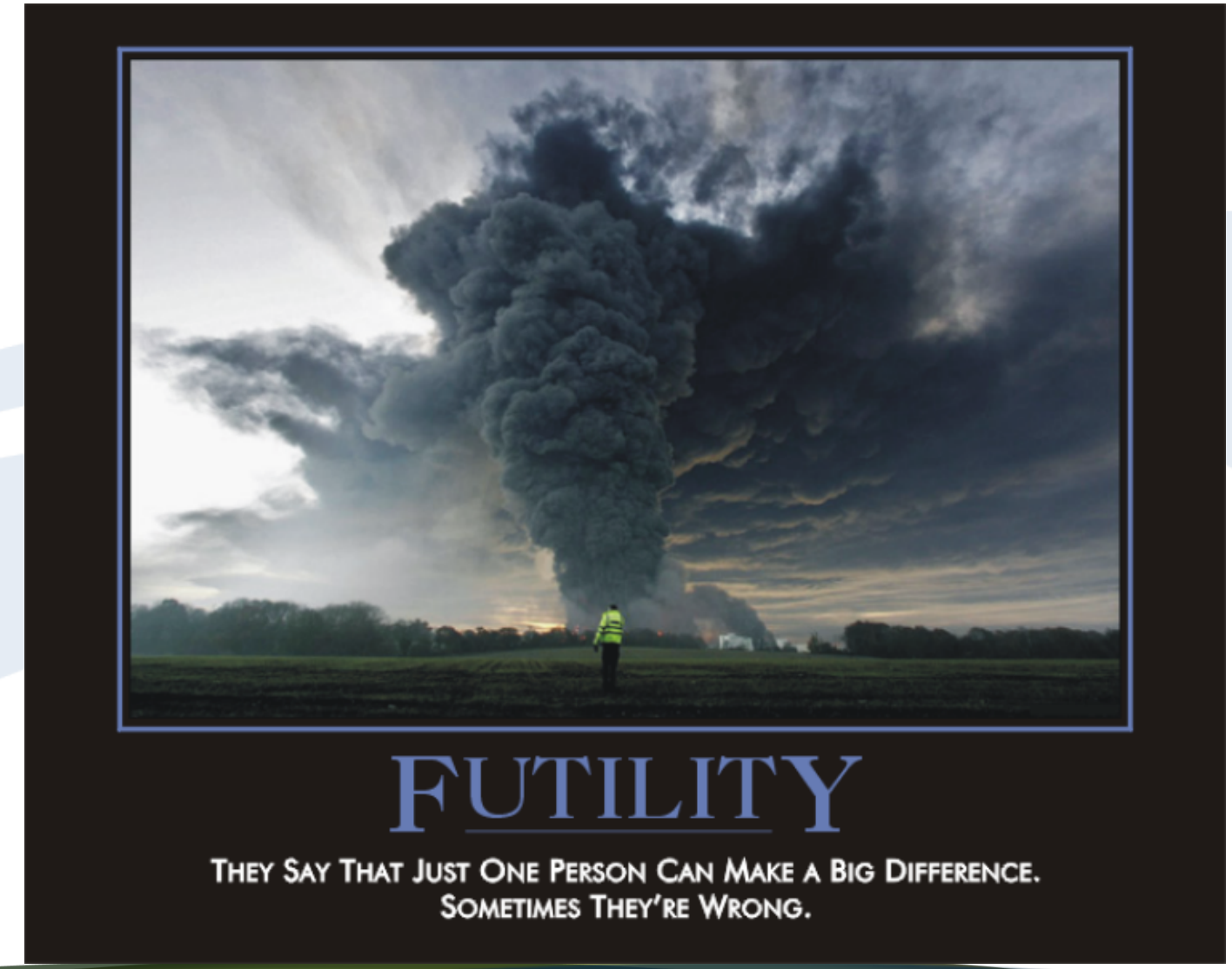
The Plan

History of project

- Question to be answered
- SAS role in helping to answer the question

Results

Implications of Results


FUTILITY
THEY SAY THAT JUST ONE PERSON CAN MAKE A BIG DIFFERENCE.
SOMETIMES THEY'RE WRONG.

ARTICLE IN PRESS

EMERGENCY MEDICAL SERVICES/ORIGINAL RESEARCH

Improved Out-of-Hospital Cardiac Arrest Survival After the Sequential Implementation of 2005 AHA Guidelines for Compressions, Ventilations, and Induced Hypothermia: The Wake County Experience

Hinchey et al. Annals of EM 2010;56:348-57

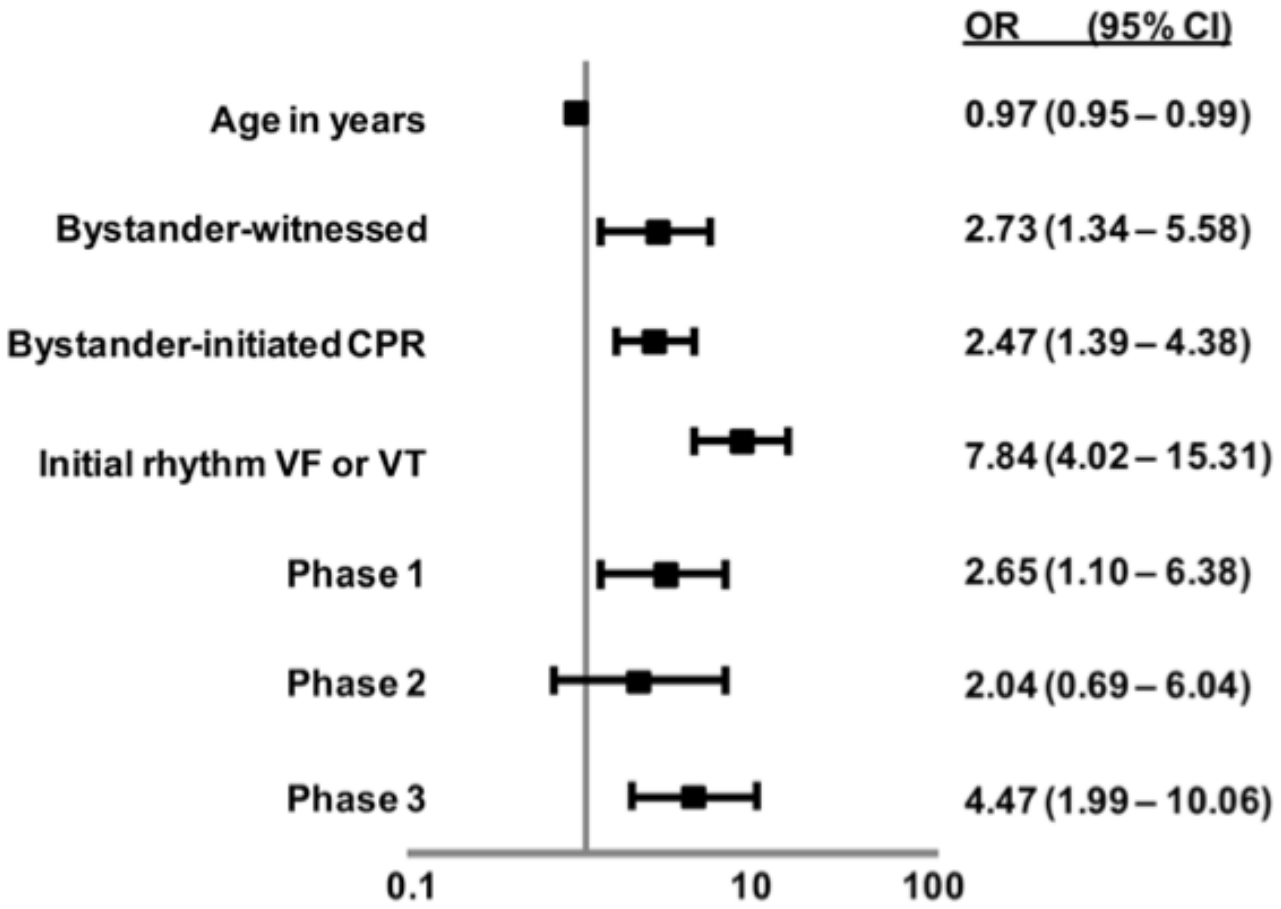
WAKE COUNTY NORTH CAROLINA

Wake County Experience

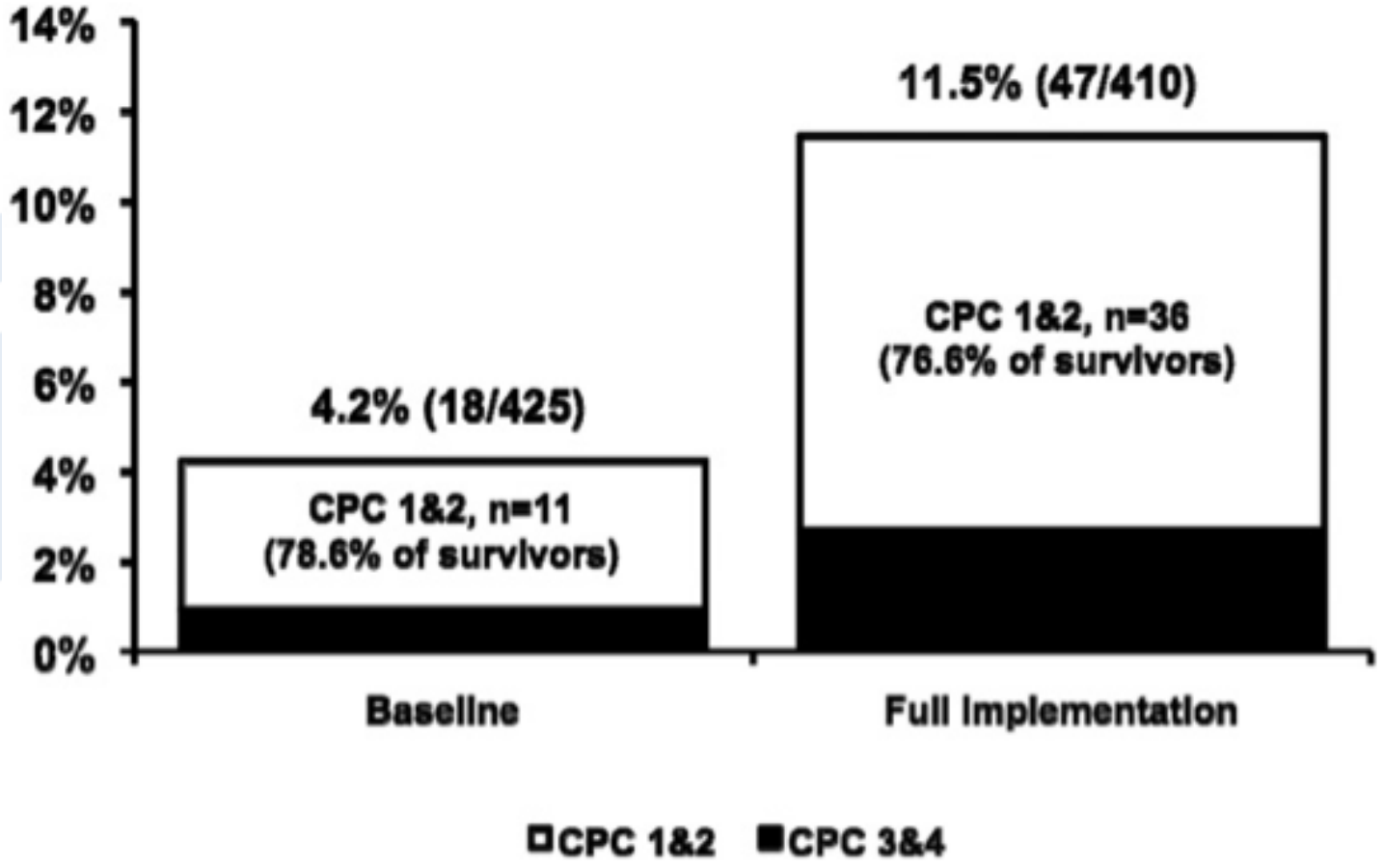
Community-wide approach to improving resuscitation outcomes
Natural experiment with prospective data collection and observation
Continuous compressions, controlled ventilations, working codes “on-scene”, and induction of hypothermia

Characteristics	Baseline (N=425)	Phase 1 (N=369)	Phase 2 (N=161)	Phase 3 (N=410)	Absolute Increase* % (95% CI)
Witnessed arrest					
Bystander witnessed	n=154	n=134	n=61	n=136	
	8 (5.2)	14 (10.4)	8 (13.1)	31 (22.8)	17.6 (9.7 to 25.5)
EMS witnessed	n=51	n=50	n=12	n=47	
	6 (11.8)	6 (12.0)	1 (8.3)	10 (21.3)	9.5 (−5.2 to 24.2)
Initial CPR					
Bystander	n=162	n=117	n=63	n=142	
	8 (4.9)	13 (11.1)	6 (9.5)	21 (14.8)	9.9 (3.2 to 16.6)
First responder (firefighter)	n=143	n=165	n=77	n=192	
	2 (1.4)	6 (3.6)	5 (6.5)	14 (7.3)	5.9 (1.7 to 10.1)
EMS response intervals					
Defib to scene in >4 min	n=356	n=287	n=121	n=330	
	16 (4.5)	16 (5.6)	9 (7.4)	35 (10.6)	6.1 (2.1 to 10.1)
Defib to scene in ≤4 min	n=42	n=70	n=39	n=73	
	1 (2.4)	9 (12.9)	4 (10.3)	12 (16.4)	11.6 (0.9 to 22.3)
Initial cardiac rhythm					
Asystole	n=200	n=178	n=81	n=199	
	3 (1.5)	2 (1.1)	1 (1.2)	4 (2.0)	0.5 (−2.1 to 3.1)
PEA	n=100	n=89	n=38	n=107	
	1 (1.0)	3 (3.4)	0 (0)	8 (7.5)	5.5 (−0.2 to 11.2)
VF or VT	n=124	n=101	n=42	n=97	
	14 (11.3)	22 (21.8)	12 (28.6)	35 (36.1)	24.8 (13.7 to 35.9)
Witnessed VF					
All-witnessed VF	n=80	n=71	n=26	n=76	
	11 (13.8)	17 (23.9)	9 (34.6)	31 (40.8)	27.0 (13.6 to 40.4)
Bystander-witnessed VF	n=61	n=56	n=24	n=66	
	5 (8.2)	12 (21.4)	8 (33.3)	23 (34.8)	26.6 (13.2 to 40.0)
EMS-witnessed VF	n=19	n=15	n=2	n=10	
	6 (31.6)	5 (33.3)	1 (50.0)	8 (80.0)	48.4 (16.0 to 80.8)

Wake County Experience



Wake County Experience



Wake County Experience

The combination of compressions, controlled ventilations, working arrests in the field, and hypothermia increased survival by 7% actually and 200% relatively

This is an increase of 3 lives saved per 100,000 population per year, or 25 additional lives saved annually in Wake County

Termination Rules

Many different studies have looked at this question
NAEMSP official position paper revision is in press
Brief review follows
Take home: we have sufficient data to adopt termination of resuscitation rules

CARES Registry Study

BLS Rule
Not witnessed by EMS
Non-shockable rhythm
No ROSC

ALS Rule
Not witnessed by EMS
Non-shockable rhythm
No ROSC
Not by-stander witnessed
No bystander CPR

CARES Registry Study

BLS Rule
PPV 99.8%
(99.6-99.9)

NPV 13.3%
(12.1-14.6)

ALS Rule
PPV 100%
(99.7-100)

NPV 9.1%
(8.3-10.0)

History of the Project

Direct Clinical Question:

- "How Long Should We Do CPR On-Scene and Still Have Reasonable Expectation of Neurologically Intact Survival?"
- Historical literature implies no more than 20 to 25 minutes
- We were seeing clinical indicators of viability well beyond 25 minutes
- We had data – SAS had analysts

History of the Project

How did SAS help?

- Multiple factors are known to impact survival
  - Age
  - Initial Cardiac Rhythm
  - Witnessed status
- Other factors seem to impact survival
  - Presence of continuous compressions
  - Controlled ventilations
  - Presence of induced hypothermia
- SAS has the ability to control for these variables

MODELING DATASET

Modeling Dataset - 2906 Observations

- Observations excluded from the Model Dataset
  - Trauma
  - Age < 16
  - Resuscitation not Attempted
  - EMS Witnessed
  - Code Not in our Control
- Variables created to provide ability to subset model
  - Treatment Phases
  - Utstein survival
  - Accuracy of time data for Length of Resuscitation

MODELING DATASET

Treatment Phases

- Phase 1: Continuous CPR — April 15, 2005 - April 17, 2006
- Phase 2: ITD — April 18, 2006 - Oct 4, 2006
- Phase 3: Hypothermia Post-ROSC — Oct 5, 2006 - April 14, 2011
- Phase 4: Hypothermia Pre-ROSC — April 15, 2011 - Dec 31, 2012

Phase	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	323	11.11	323	11.11
2	146	5.02	469	16.14
3	1686	58.02	2155	74.16
4	751	25.84	2906	100.00

WAKE COUNTY EMS DATA TREND BY PHASE (MODEL DATASET)

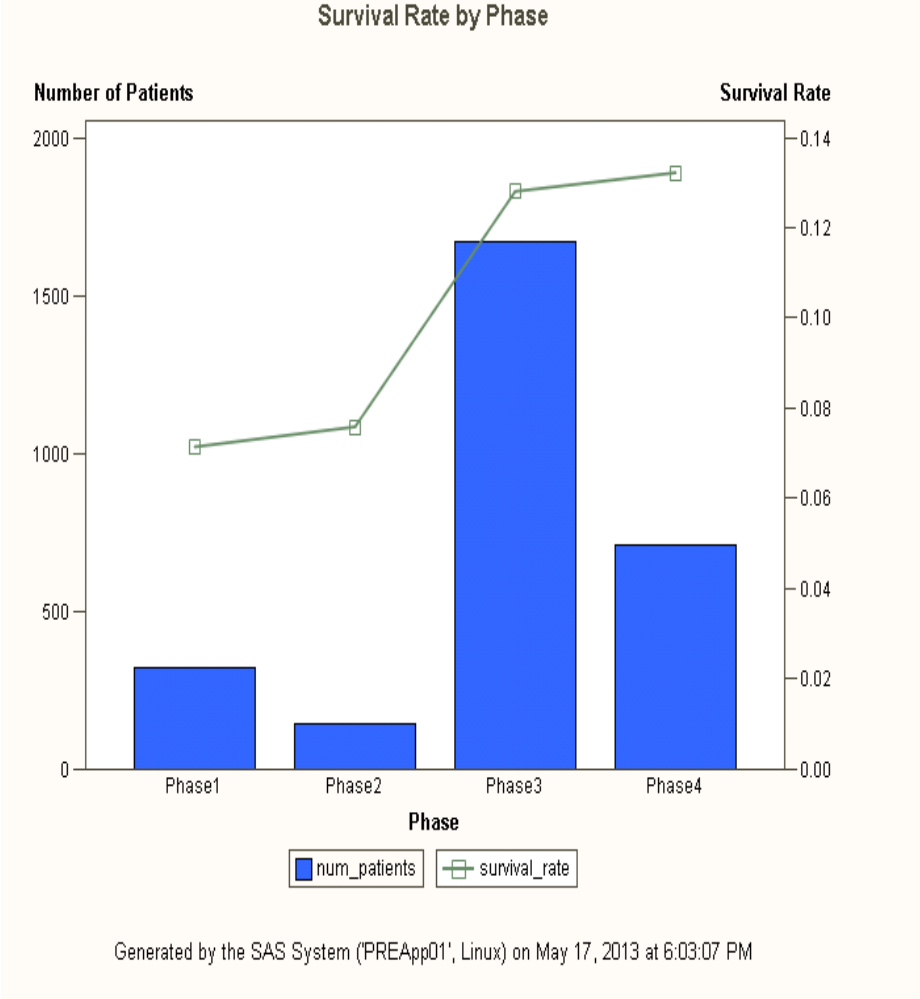


Table of target_survived by Phase						
		Phase				
		1	2	3	4	Total
target_survived						
0	Frequency	300	135	1471	637	2543
	Col Pct	92.88	92.47	87.25	84.82	
1	Frequency	23	11	215	114	363
	Col Pct	7.12	7.53	12.75	15.18	
Total	Frequency	323	146	1686	751	2906

Statistic	DF	Value	Prob
Chi-Square	3	16.8754	0.0007
Likelihood Ratio Chi-Square	3	18.4333	0.0004
Mantel-Haenszel Chi-Square	1	16.1265	<.0001
Phi Coefficient		0.0762	
Contingency Coefficient		0.0760	
Cramer's V		0.0762	

WAKE COUNTY EMS DATA TREND BY PHASE (MODEL DATASET)

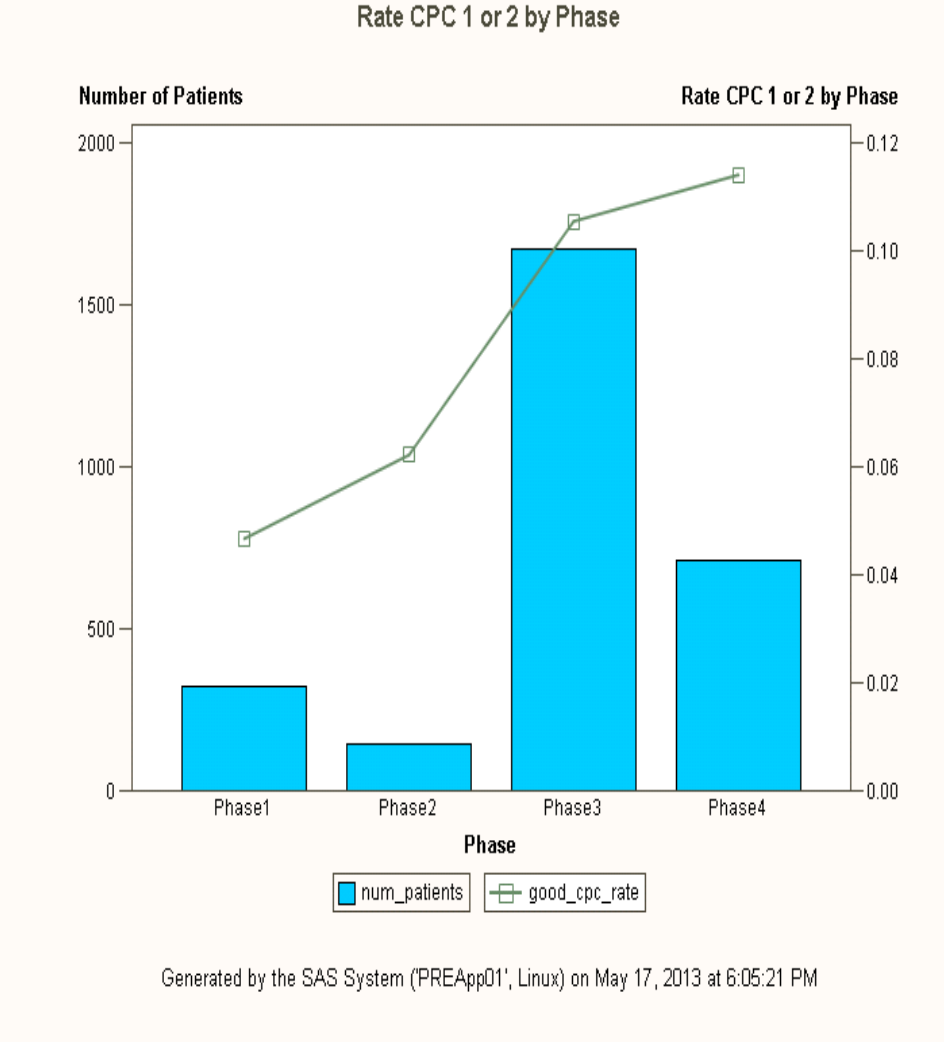
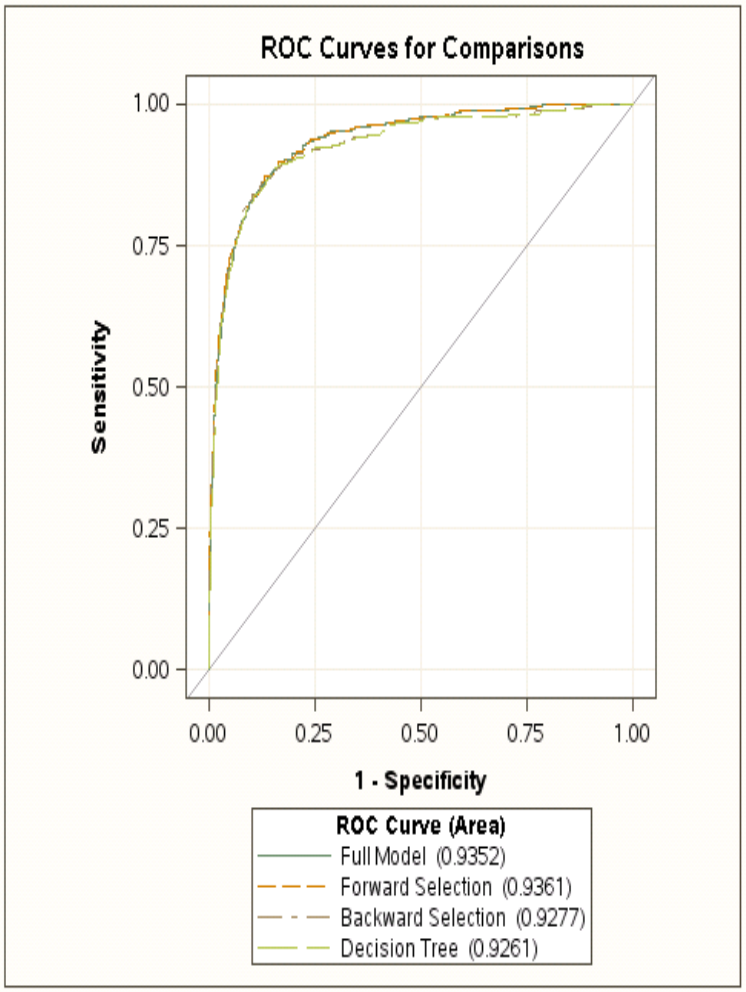


Table of target_cpc by Phase						
		Phase				
		1	2	3	4	Total
target_cpc						
0	Frequency	308	137	1509	652	2606
	Col Pct	95.36	93.84	89.50	86.82	
1	Frequency	15	9	177	99	300
	Col Pct	4.64	6.16	10.50	13.18	
Total	Frequency	323	146	1686	751	2906

Statistic	DF	Value	Prob
Chi-Square	3	20.6685	0.0001
Likelihood Ratio Chi-Square	3	23.2124	<.0001
Mantel-Haenszel Chi-Square	1	20.3576	<.0001
Phi Coefficient		0.0843	
Contingency Coefficient		0.0840	
Cramer's V		0.0843	

WAKE COUNTY EMS | LOGISTIC REGRESSION RESULTS



ROC Association Statistics								
	Mann-Whitney							
ROC Model	Area	Standard Error	95% Wald Confidence Limits		Somers' D (Gini)	Gamma	Tau-a
Full Model	0.9352	0.00712	0.9213	0.9492	0.8704	0.8704	0.1868
Forward Selection	0.9361	0.00713	0.9221	0.9501	0.8722	0.8722	0.1872
Backward Selection	0.9277	0.00831	0.9114	0.9439	0.8553	0.8553	0.1835
Decision Tree	0.9261	0.00835	0.9097	0.9424	0.8521	0.8521	0.1829

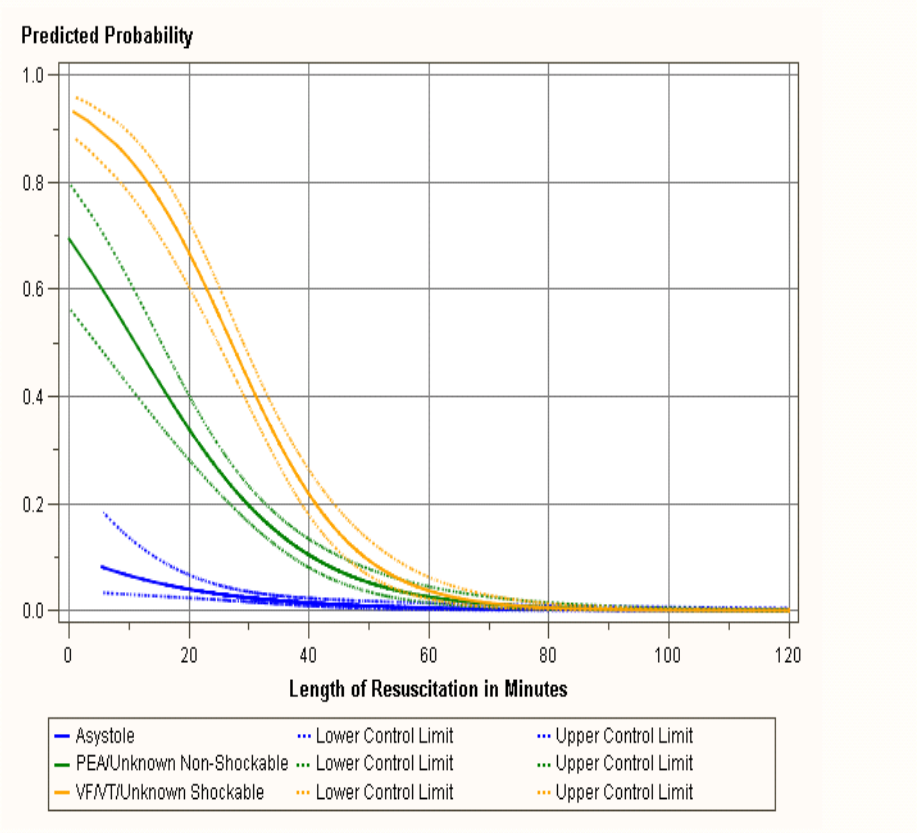
ROC Contrast Test Results			
Contrast	DF	Chi-Square	Pr > ChiSq
Overlay of ROC Curves	3	17.5447	0.0005

ROC Contrast Estimation and Testing Results by Row						
		Standard	95% Wald			
Contrast	Estimate	Error	Confidence Limits		Chi-Square	Pr > ChiSq
Full Model - Forward Selection	-0.00089	0.000602	-0.00207	0.000293	2.1685	0.1409
Full Model - Backward Selection	0.00757	0.00260	0.00246	0.0127	8.4511	0.0036
Full Model - Decision Tree	0.00917	0.00258	0.00412	0.0142	12.6516	0.0004
Forward Selection - Backward Selection	0.00845	0.00241	0.00373	0.0132	12.3250	0.0004
Forward Selection - Decision Tree	0.0101	0.00255	0.00505	0.0151	15.5228	<.0001
Backward Selection - Decision Tree	0.00160	0.000797	0.000039	0.00316	4.0346	0.0446

WAKE COUNTY EMS

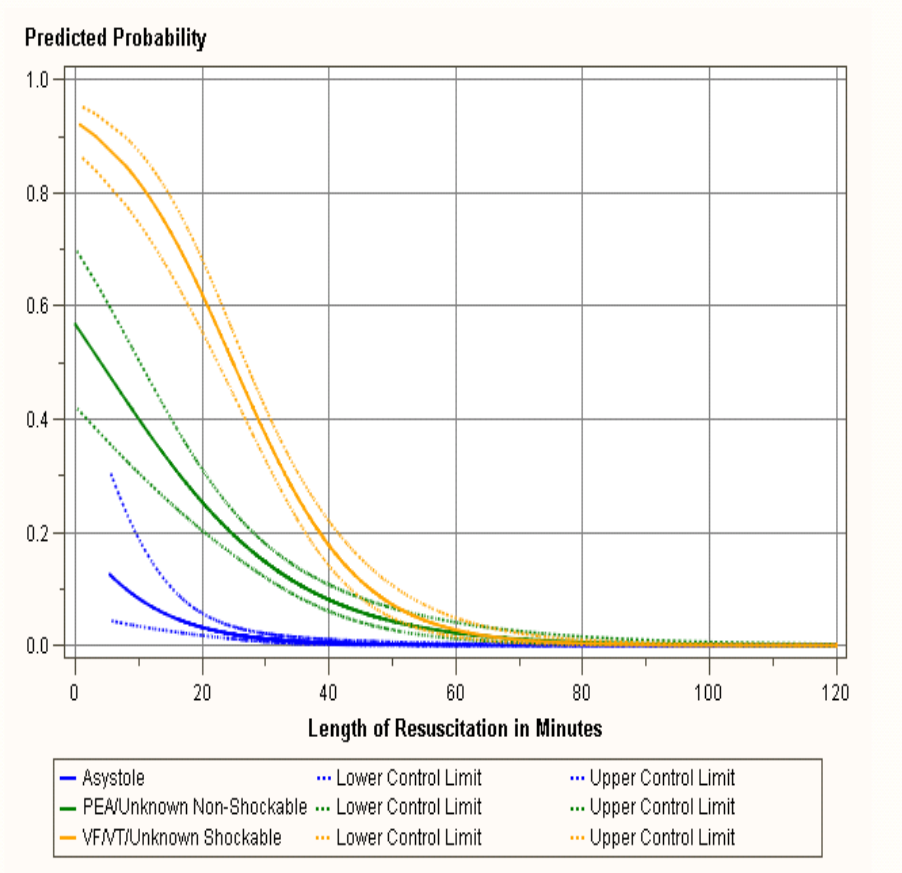
PREDICTED SURVIVAL PROBABILITY BY INITIAL RHYTHM

LOR minutes	Asystole	VF/VT/ Shockable	PEA/ Non Shockable
10	0.0653	0.8445	0.5192
15	0.0502	0.7679	0.4267
20	0.0397	0.6685	0.3391
25	0.0308	0.5513	0.2613
30	0.0239	0.4281	0.1960
35	0.0185	0.3132	0.1439
40	0.0143	0.2175	0.1038
45	0.0110	0.1448	0.0740
50	0.0085	0.0935	0.0522
55	0.0066	0.0592	0.0366
60	0.0050	0.0369	0.0255



WAKE COUNTY EMS | PREDICTED PROBABILITY CPC=1,2 BY INITIAL RHYTHM

LOR minutes	Asystole	VF/VT/ Shockable	PEA/ Non Shockable
10	0.0830	0.8188	0.4003
15	0.0503	0.7312	0.3225
20	0.0320	0.6207	0.2535
25	0.0196	0.4962	0.1950
30	0.0119	0.3722	0.1473
35	0.0072	0.2629	0.1097
40	0.0044	0.1767	0.0808
45	0.0027	0.1144	0.0590
50	0.0016	0.0721	0.0428
55	0.0010	0.0447	0.0309
60	0.0006	0.0274	0.0222



Wake County EMS
331 South McDowell St.
Raleigh, NC 27601

WakeMed Health & Hospitals
3000 New Bern Ave.
Raleigh, NC 27610

MW Bachman, MHS, EMT-P[1]; JG Williams, MD, MPH[1,2]; JB Myers, MD, MPH[1]; K Hart, MA, MSA[3]; J Zalkin BS, EMT-P[1]; VJ De Maio, MD, MSc[2]

[1]Wake County, NC Emergency Medical Services; [2] Clinical Research Unit, Emergency Services Institute, WakeMed Health and Hospitals; [3] SAS Institute, Cary, NC

Duration of Prehospital Resuscitation For Adult Out-of-Hospital Cardiac Arrest: Neurologically Intact Survival Approaches Overall Survival Despite Extended Efforts

OBJECTIVE

- Out-of-hospital cardiac arrest (OHCA) guidelines suggest resuscitation beyond 30 minutes may be futile.
- Few studies address neurologic outcome for survivors of extended duration OHCA.
- The duration of prehospital resuscitation (DOR) that yields a reasonable probability of neurologically intact survival (NIS) is unknown.
- We assess whether DOR affects NIS from OHCA.

METHODS

- We conducted a retrospective cohort study of all OHCA patients in our urban/suburban advanced life support EMS system (pop 950,000) from 2005–2012.
- Excluded were resuscitations not attempted, age < 16, trauma patients, and EMS-witnessed arrests.
- DOR was measured from time of dispatch to end of prehospital resuscitation, defined by first return of spontaneous circulation, en-route hospital, or death.
- Primary outcome was NIS, defined as cerebral performance category (CPC) 1 or 2 at hospital discharge.
- Multivariate logistic regression determined the odds ratios with 95% confidence intervals (CI) for both survival and NIS adjusted for DOR and factors determined to have a significant relationship with NIS at the univariate level.

Fig 1. All Survivors and Neurologically Intact Survivors by DOR, with 90th Percentile DOR (40 minutes) Highlighted

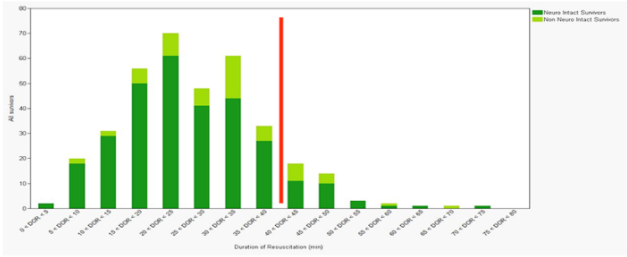


Fig 2. Predicted Probability of Survival with CPC 1 or 2 across Duration of Resuscitation, by Initial Rhythm (unadjusted)

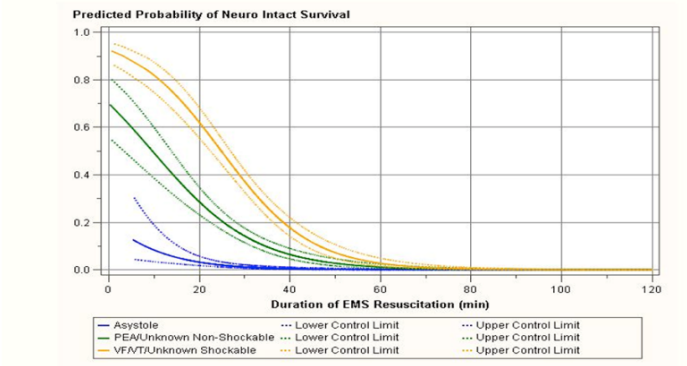
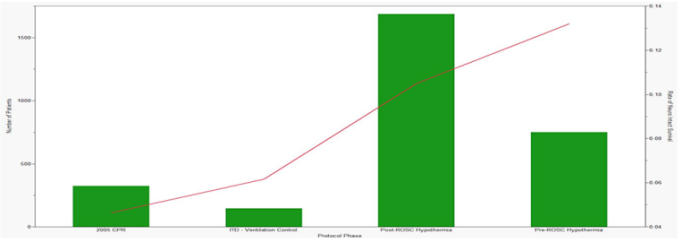


Fig 3. Wake County EMS OHCA cases by protocol phase, with rate of Neurologically Intact Survival



RESULTS

- Of 2905 eligible OHCA, patients were: mean age 64.6 years (sd=17.0) male 60.1%, bystander witnessed 38.9% and had bystander CPR 37.2%. Overall, 362 survived (12.5%) and 300 had NIS (82.9% of survivors). Median defibrillator to scene was 7 minutes (IQR 5-9).
- Overall median DOR was 38 min (IQR 29-48), with median DOR for NIS of 24 min (IQR 18-32). **The 90th percentile for NIS was 40 min.** Beyond 40 min, 29/42 survivors (69%, 95% CI 54-81%) were neurologically intact. The longest resuscitation that achieved NIS was 73 min.
- Controlling for OHCA protocol changes over time ("protocol phase"), adjusted OR (95% CI) was 0.91 (0.90-0.92) for both survival and NIS. Other predictors of NIS across models were initial rhythm, age, bystander witness, therapeutic hypothermia, and absence of advanced airway.

CONCLUSIONS

- In a retrospective analysis of OHCA, DOR is associated with declining survival and NIS, with NIS approximating the overall survival curve. DOR was within 40 minutes from time of dispatch for 90% of NIS. A large number of patients survived neurologically intact with DORs greater than previous guidelines would suggest. Further study should examine factors predictive of NIS in longer resuscitations.

Conclusions

- 90 percent of neurologically intact survivors had ROSC at 40 minutes of resuscitation
- 29 of 42 survivors with resuscitation beyond 40 minutes had NIS (69%, (CI 54-81%)).
  - Presence of continuous compressions
  - Controlled ventilations
  - Presence of induced hypothermia
- SAS has the ability to control for these variables

Implications

What Does This Mean?

- If we had followed the 25 minute rule, ~ 100 neurologically-intact survivors would have had their resuscitative efforts abandoned prematurely
- Prolonged resuscitative efforts with continuous compressions, controlled ventilations, and hypothermia can reliably produce neurologically intact survivors
- The next steps are:
  - National scientific presentation in January, 2014
  - Manuscript preparation for peer review publication
  - Analysis of physiologic parameters to assist with prediction

Discussion