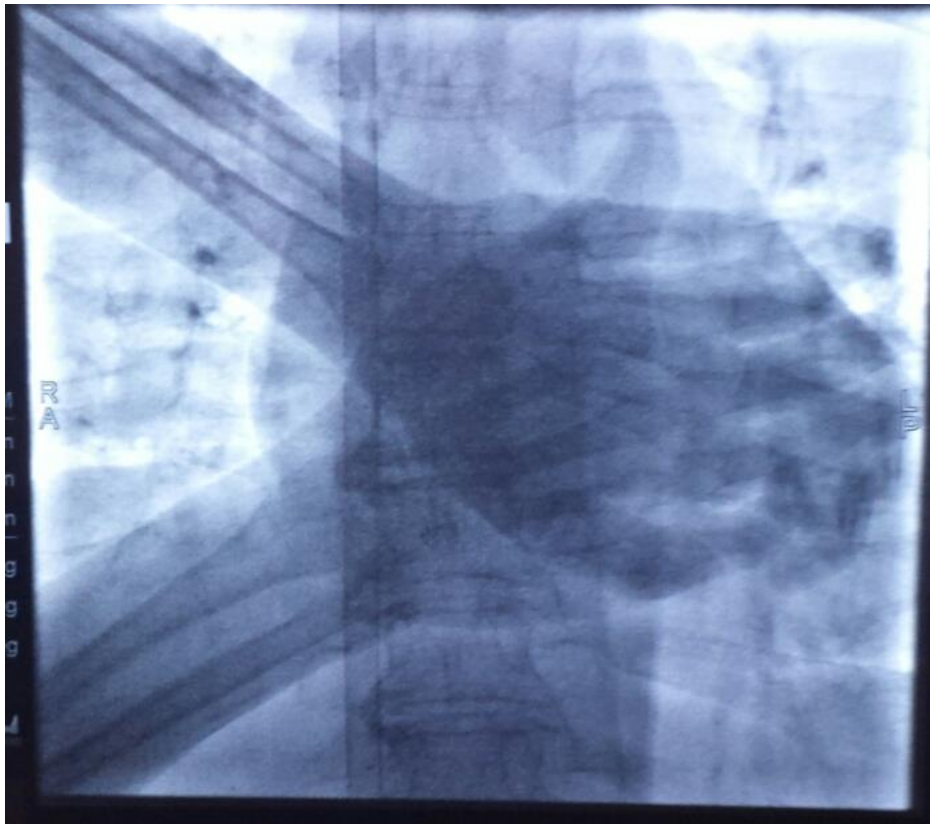
Cardiac Arrest:
Can Education Improve Outcomes?



Lorrel E. Brown, MD

Assistant Professor of Medicine

Director of Resuscitation, ULH

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DISCLOSURES

- No disclosures
- No discussion of off-label drug use

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LEARNING OBJECTIVES

At the completion of this lecture, participants will be able to:

1. Understand postulated reasons for the variability in survival following cardiac arrest, both in- and out-of-hospital.
2. Identify the gaps between best practices and real-world practices with regards to cardiac arrest management.
3. Recognize ways in which ongoing educational efforts seek to improve outcomes following cardiac arrest.

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Problem…

- 350,000 Out of Hospital Cardiac Arrest (OHCA) annually[1]
- Average survival 10.8%[1]
- Up to 5-fold Geographic variation in OHCA survival[2]

1. Mozafarrian *et al.*, Circulation 2015
2. Nichol *et al.*, JAMA 2008

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Problem…

- 210,000 In Hospital Cardiac Arrest (IHCA) annually[1]
- Average unadjusted survival 24.8%[1]
- Up to 3-fold variation between hospitals in IHCA survival[2]

1. Mozafarrian *et al.*, Circulation 2015
2. Chan *et al.*, JAMA Cardiology 2016

…and Opportunity

Each **1%** increase in OHCA survival →

3,500 more survivors per year

Each **1%** increase in IHCA survival →

2,000 more survivors per year

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OUT-OF-HOSPITAL CARDIAC ARREST

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Factors Influencing OHCA Survival

Arrest Characteristics	Patient Characteristics
Witnessed	Age
Shockable Rhythm	Gender
ROSC in field	Race
Public Location	
Time to defibrillation	
Bystander CPR	

Sasson *et al.,* Circ Quality & Outcomes 2009
Girotra *et al.*, Circulation 2016

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Combined effect of delay to CPR and defibrillation on survival

Collapse to CPR, min	Collapse to Defib, min		
		≤ 10	> 10
	≤ 5	506/1388 (37%)	4/59 (7%)
	> 5	68/336 (20%)	0/89 (0%)

"Decrease in survival by 8 to 10% for every minute delay after collapse to defibrillation"

Valenzuela T D *et al.,* Circulation 1997

Problem…

- Bystander CPR improves OHCA survival[1,2]
- BUT Overall rate of bystander CPR low (31%); lower in rural, low income, minority communities[3]
- Variation in survival correlates with variation in rates of bystander CPR[4,5]

1. Nichol *et al.*, JAMA 2008
2. Sasson *et al.*, Circ Cardiovasc Qual Outcomes 2010
3. Bobrow *et al.*, JAMA 2010
4. Current *et al.*, National Academies Press 2015
5. Girotra *et al.*, Circulation 2016

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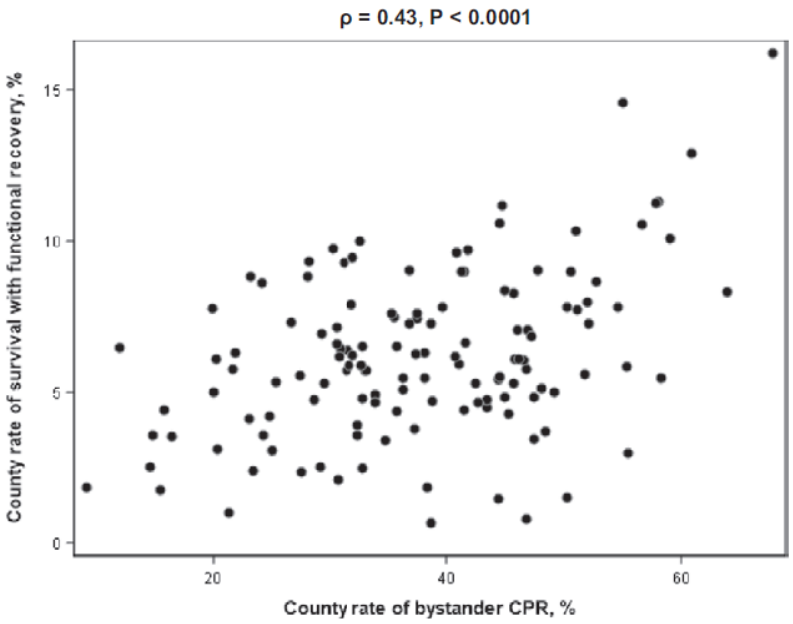
Table 3. Variation in Survival Outcomes and Proportion of Explained Variation

	Median OR for County Effect (95% CI)	Percent Variation Explained, %
Survival with functional recovery		
Unadjusted	1.53 (1.43–1.62)	–
Adjusted for demographics*	1.50 (1.41–1.58)	10.9
Adjusted for demographics and cardiac arrest characteristics†	1.44 (1.35–1.51)	27.7
Adjusted for demographics, cardiac arrest characteristics, and bystander response (CPR and AED)‡	1.40 (1.32–1. 74)	37.2
Adjusted for demographics, cardiac arrest characteristics, bystander response (CPR and AED), and county-level sociodemographic characteristics§	1.35 (1.28–1.42)	49.9



- Rate of survival correlates with rate of bystander CPR
- Bystander CPR explains ~10% of variability in survival with functional recovery

Girotra *et al.*, Circulation 2016

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Table 2
Predictors of CPR Performance: All Bystanders, Multivariable

Predictor	OR (95% CI)	p-value
Male bystander	1.42 (0.89, 2.28)	0.14
Family bystander	1.15 (0.64, 2.07)	0.63
Public location	3.13 (1.69, 5.79)	<0.001
Witnessed arrest	2.30 (1.39, 3.79)	0.001
Bystander CPR trained	6.63 (3.51, 12.5)	0.001
Bystander has more than high-school education	1.95 (1.23, 3.09)	0.004
Bystander age	2.30 (1.39, 3.79)	0.001
Patient age	0.99 (0.97, 1.01)	0.12

Hosmer-Lemeshow = 0.625. Bystander is defined as the individual who called 911, or who caused 911 to be called.
CPR = cardiopulmonary resuscitation; OR = odds ratio.

Swor *et al.,* Acad Emerg Med 2006

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…and Opportunity

- **Bystander CPR** is most modifiable factor influencing OHCA survival
- AND **CPR training** is strongest predictor of performing bystander CPR
- THEREFORE, by increasing rate of CPR training, we can **improve OHCA survival**.

American Heart Association

31% → **62%**[1]

1. Neumar *et al.*, Circulation 2015

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The NEW ENGLAND JOURNAL of MEDICINE

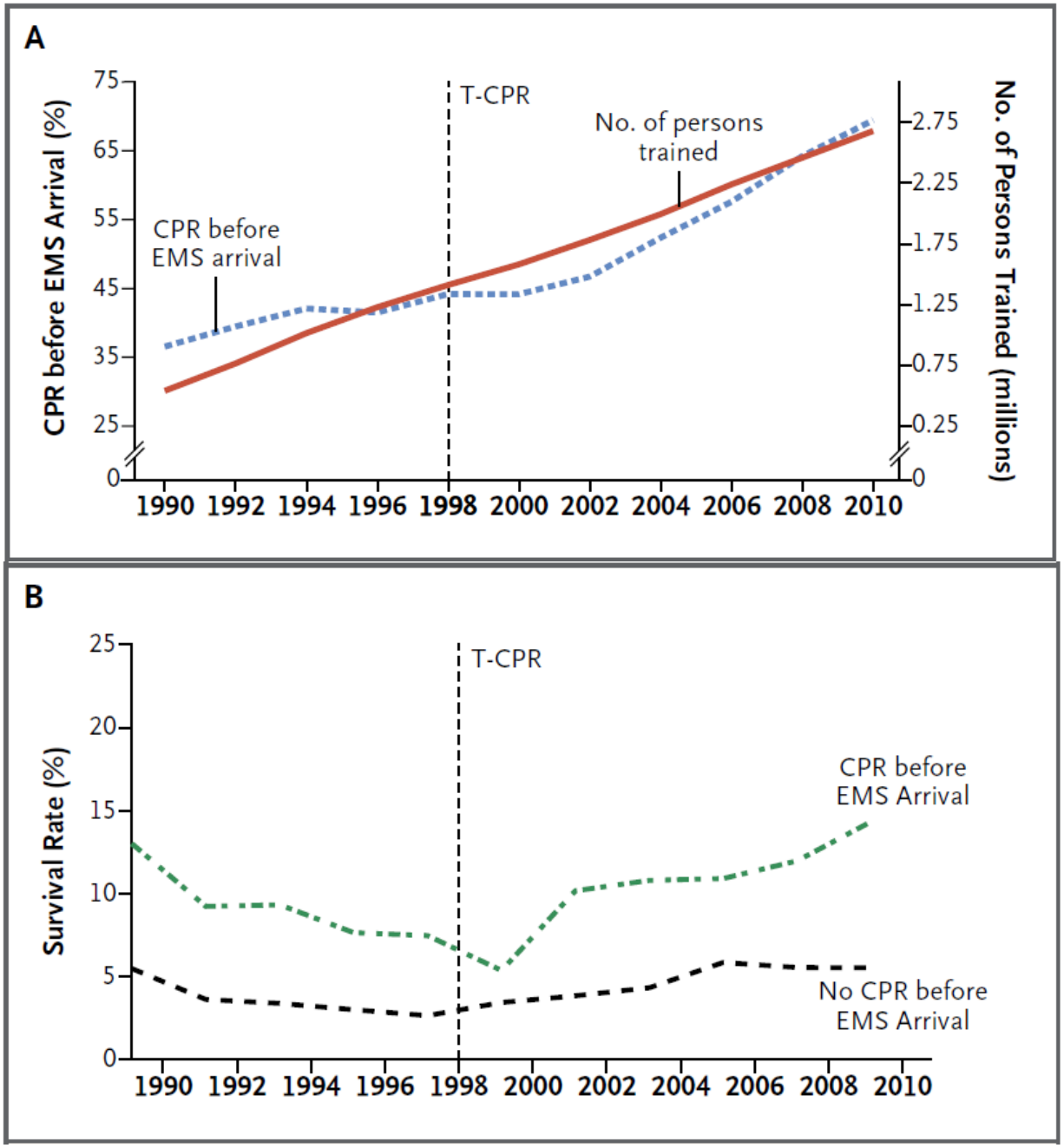

Figure 1. Changes over Time in CPR Training, the Performance of Early CPR, and Survival Rates.
Panel A shows number of persons in Sweden who were trained in CPR and the proportion of patients in whom CPR was started before arrival of EMS. Panel B shows the survival rate when CPR was given and when CPR was not given before EMS arrival.

Hasselqvist *et al.,* NEJM 2015

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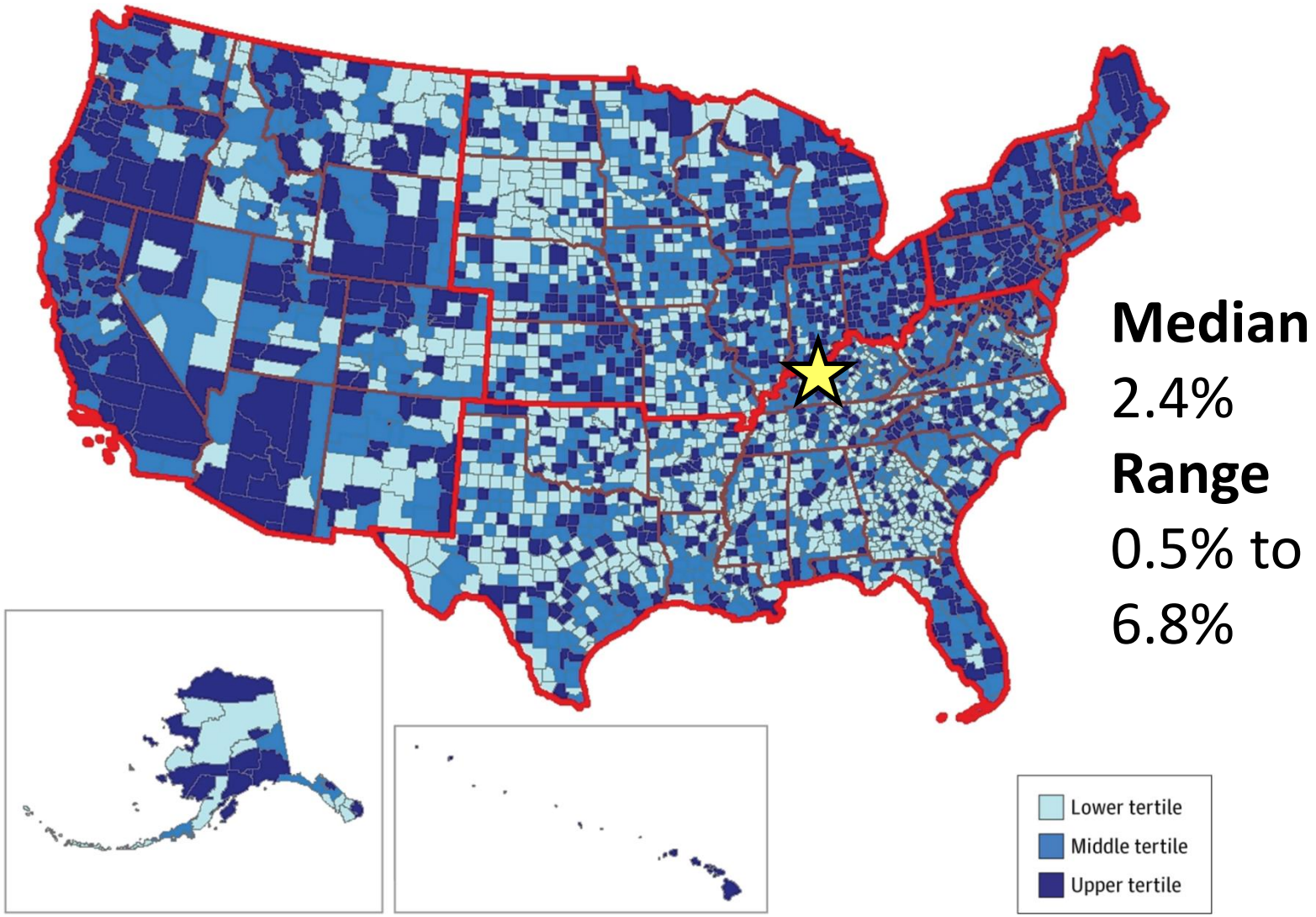
Rates of CPR Training in the United States

The JAMA Network



Anderson *et al.,* JAMA Intern Med. 2014

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"Initiatives designed to increase bystander CPR must overcome barriers…. And teach the technical skill to perform CPR with confidence."

"Increased efforts to reach communities and populations where disparities are prevalent."

Current *et al.*, National Academies Press 2015

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Multi-Sensory CPR Training

- Novel approach to CPR training:
  - ❖1-min AHA video “Hands-only CPR”
  - ❖Active coaching
  - ❖Public venue
- Strategically target state fair attendees
  - ❖Diverse
  - ❖Likely from areas with low rates of bystander CPR

Methods

ACTIVITY	TIME
AHA Hands-Only CPR Video	1 min
Practice CPR with active coaching	2 min
Timed round of CPR	1 min

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Results

- **Participants:**

  152 adults

  66 minors

- **Return for CPR skills retention testing:**

  11% (N = 17)

- **Training efficiency index:**

  4.6 participants per personnel-hr

  [(218 participants)/(47 personnel-hrs.)]

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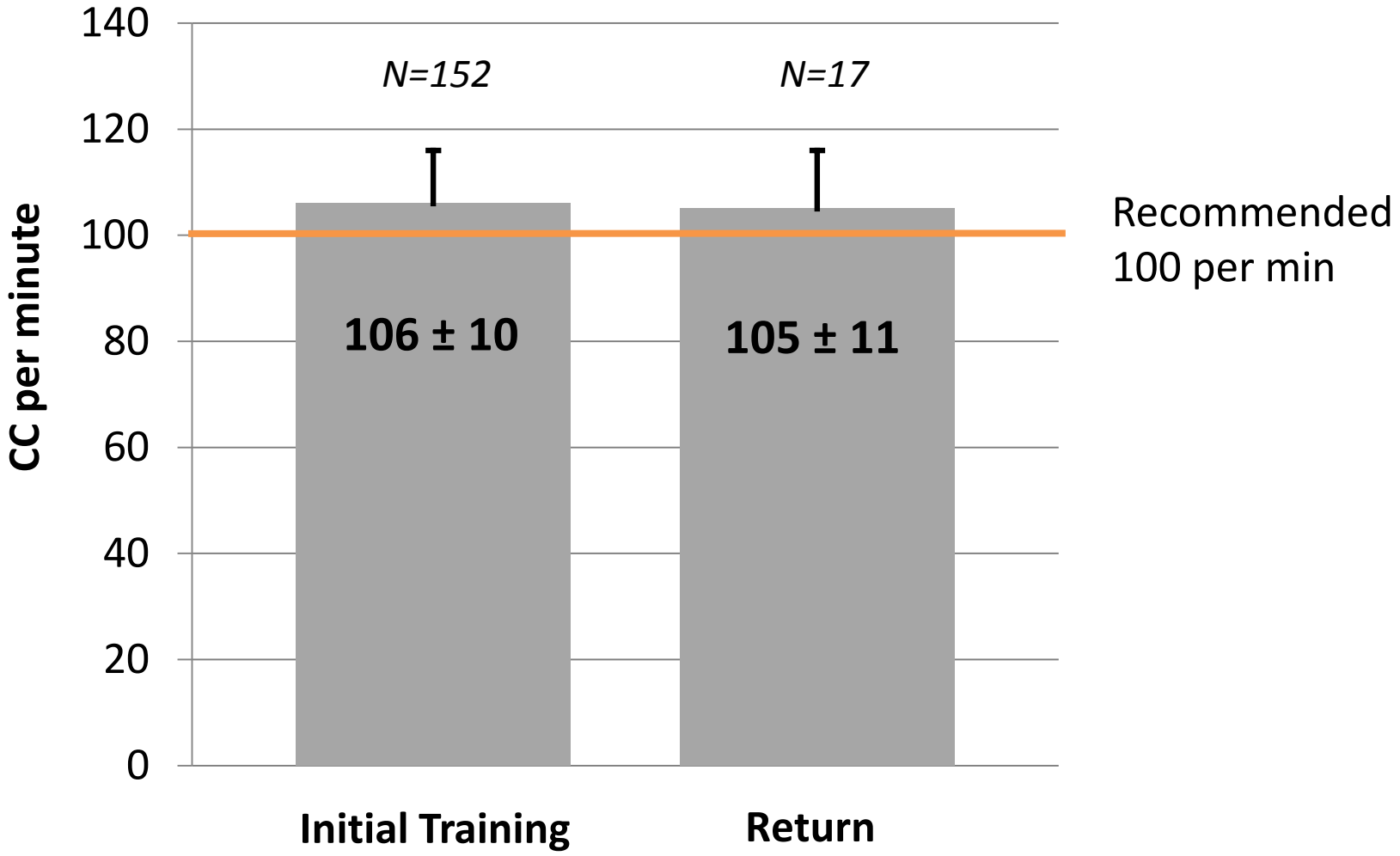
Chest Compression Rate



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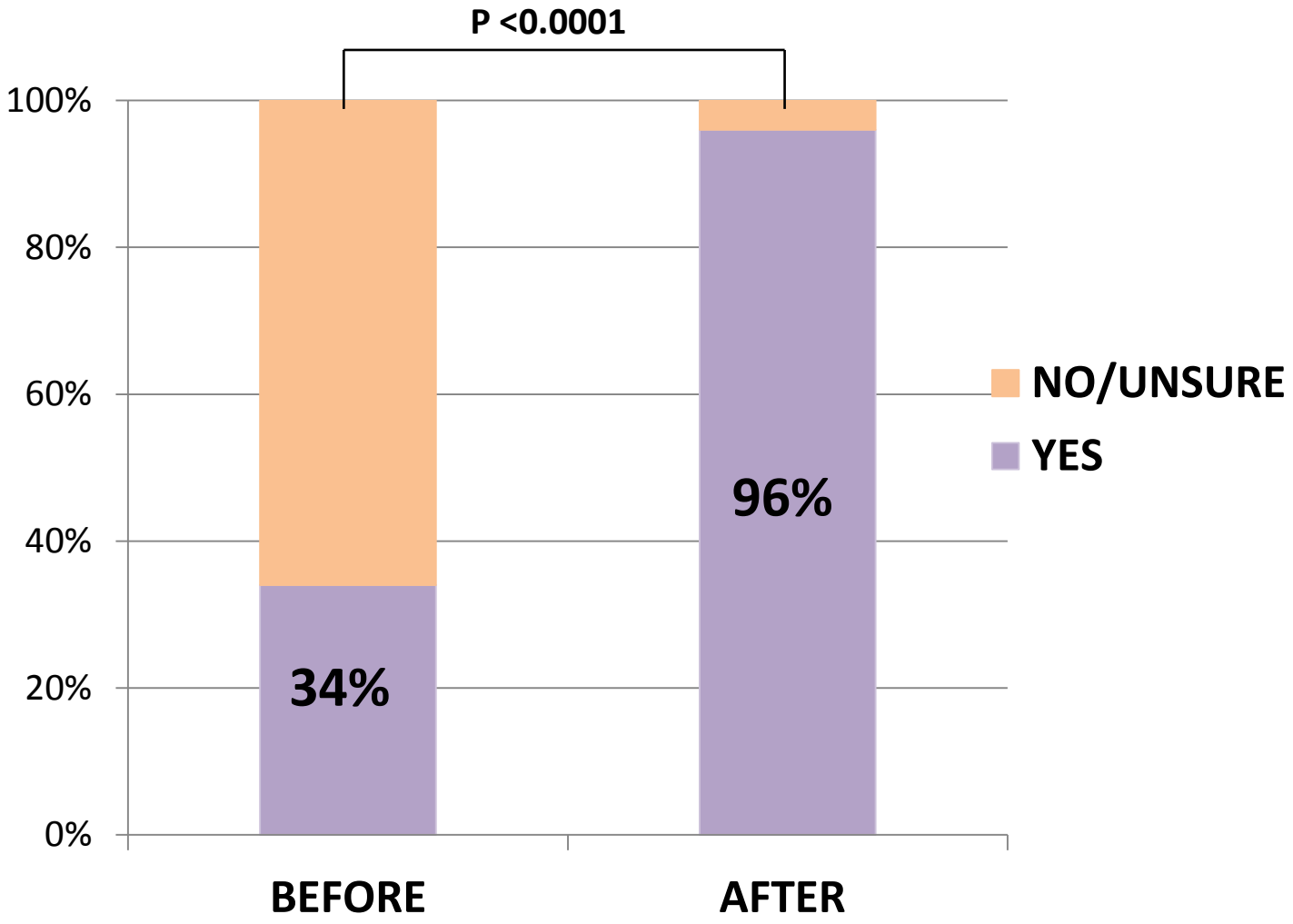
Q: Do you know how to perform CPR?



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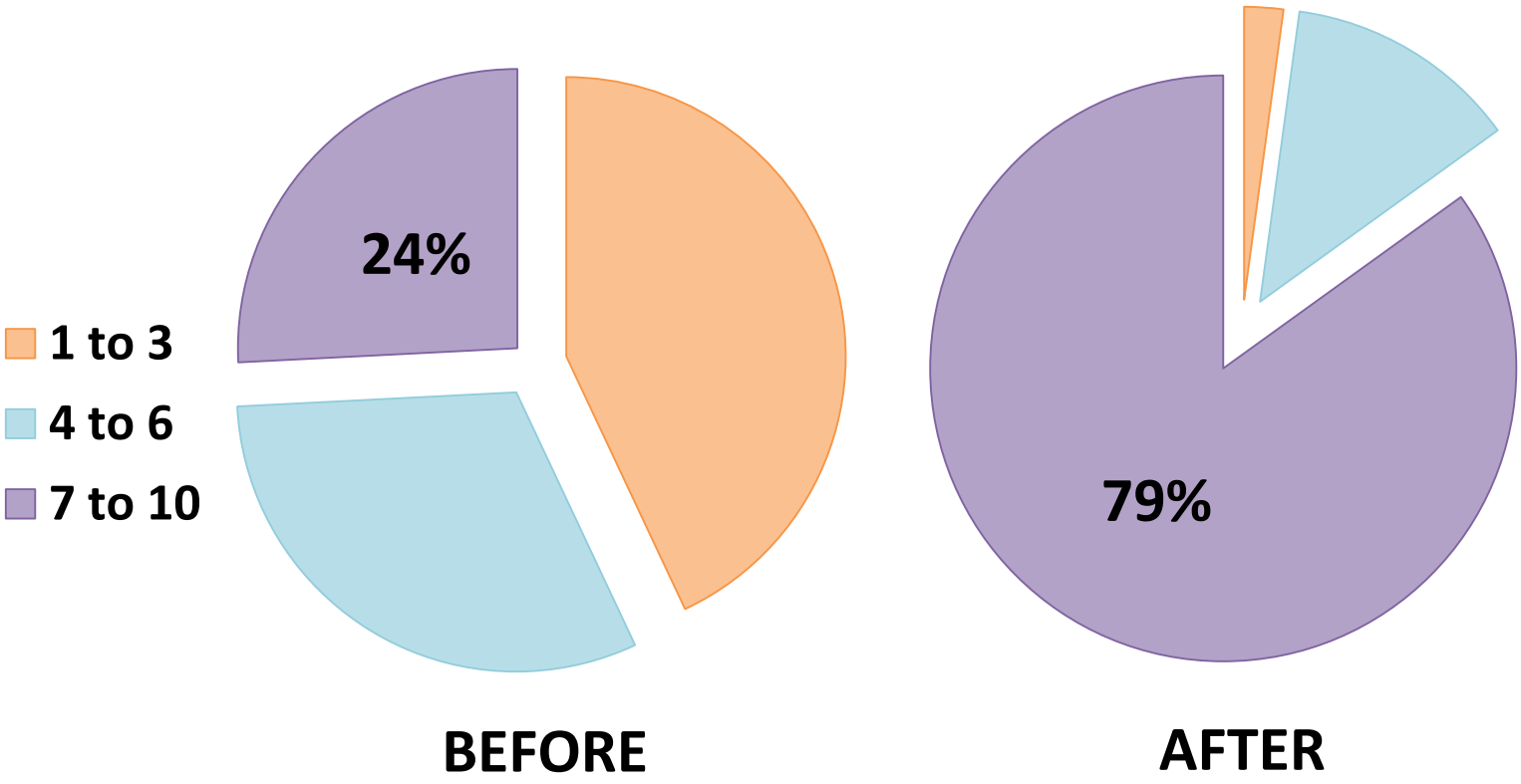
Q: How confident are you in performing CPR?

Scale of 1 to 10, 10 is most confident



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Did this strategy successfully target people from communities with low rates of bystander CPR?

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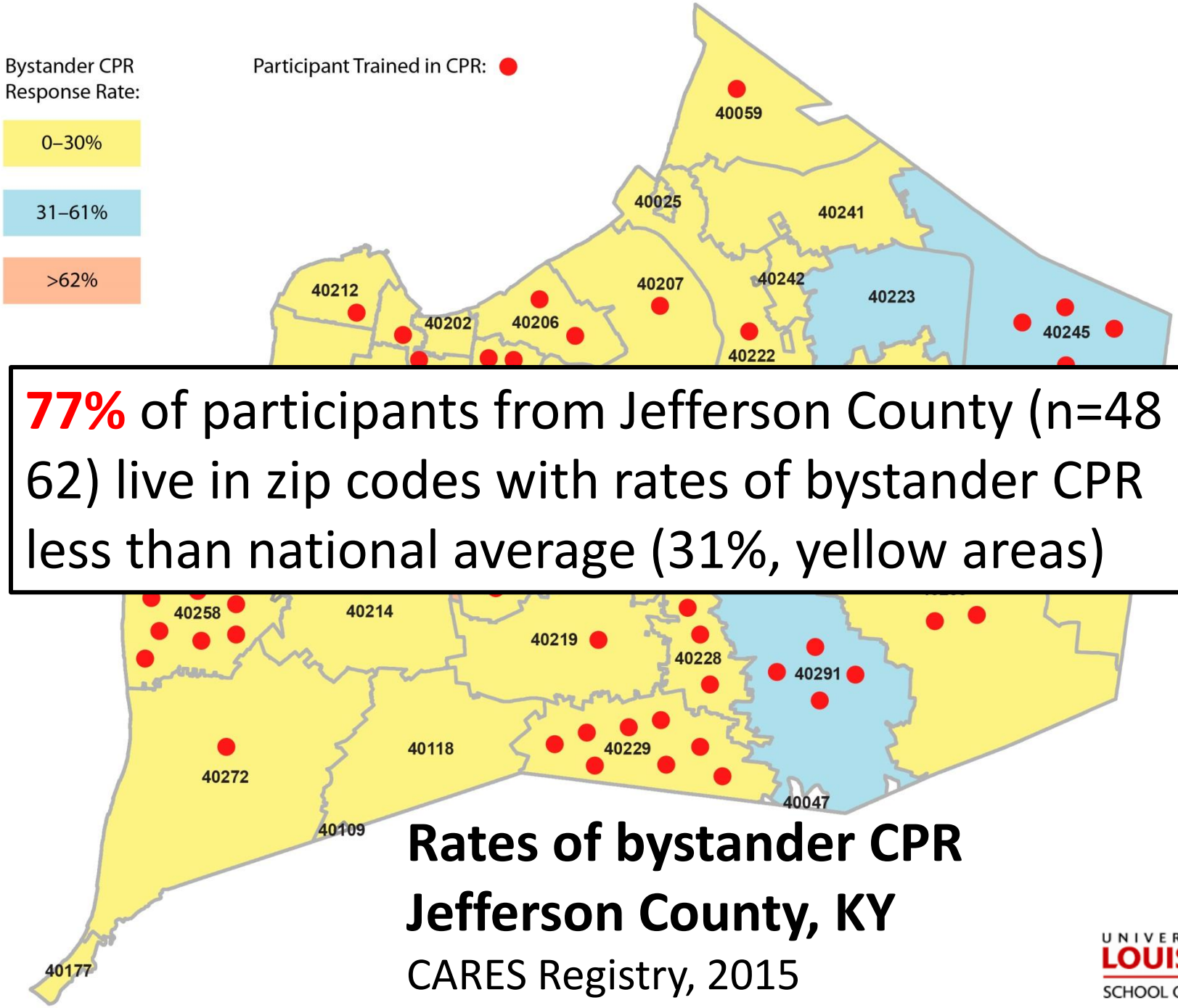

77% of participants from Jefferson County (n=48 of 62) live in zip codes with rates of bystander CPR less than national average (31%, yellow areas)

Rates of bystander CPR
Jefferson County, KY
CARES Registry, 2015

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Widespread Implementation

CPR Trained:

1033

CPR Aware:

3.3 million

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IN-HOSPITAL CARDIAC ARREST

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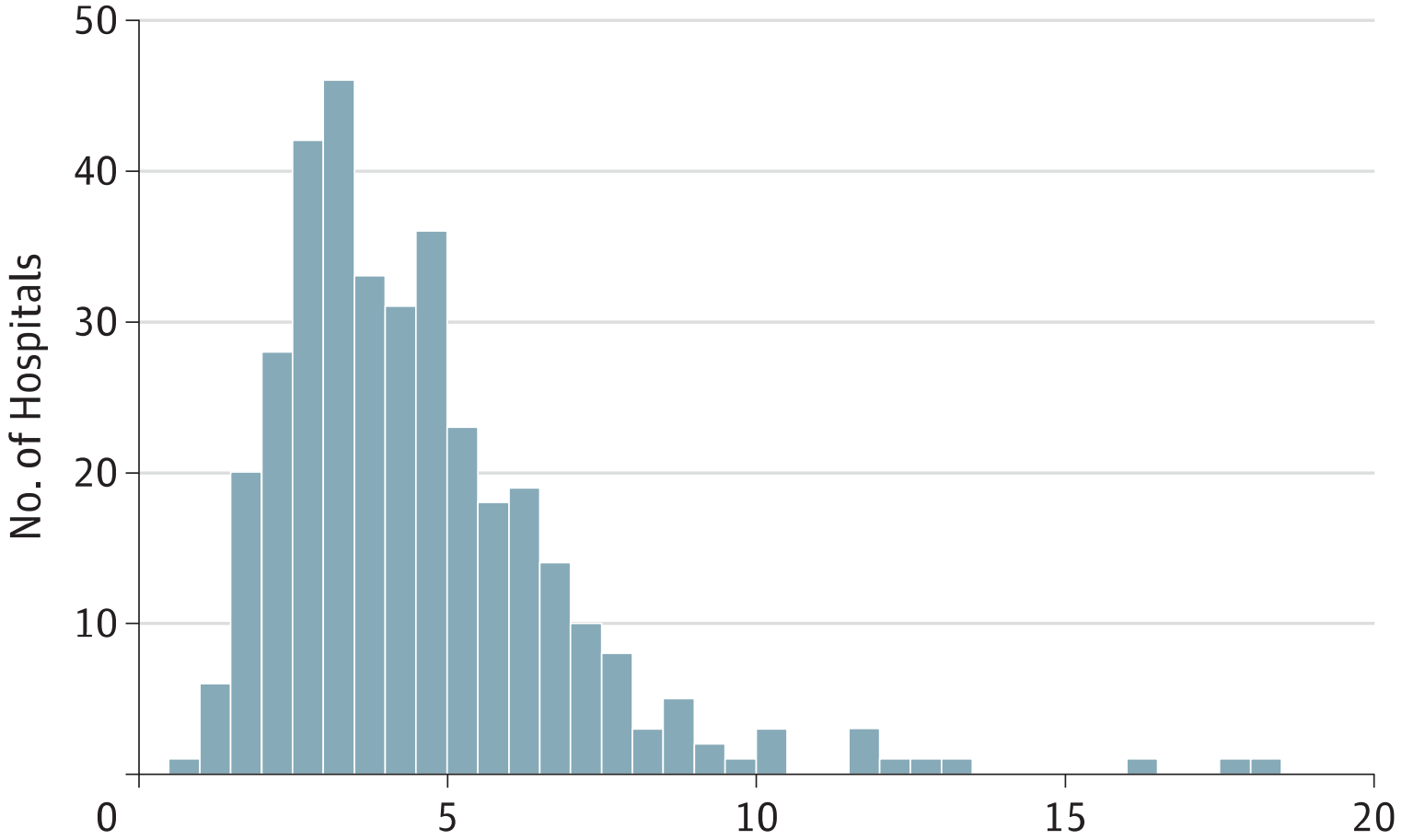
IHCA Incidence Rate, per 1000 admissions



Chan *et al.*, Arch Intern Med 2010

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Hospital Type	Unadjusted Survival Rate (range)
Academic	18.6% (0 to 51.7%)
Large Bed Size (≥400)	19.1% (0 to 42.3%)
Urban	17.9% (0 to 51.7%)

"The hospital to which one is admitted may influence one's odds of survival by 42%, an enormous effect considering this is a 'hard' clinical endpoint."

"These differences can be influenced by the quality of hospital personnel training, adherence to evidence-based protocols, and implementation of internal quality control mechanisms."

Merchant *et al.* JAHA 2014
Graham *et al.* IOM Report 2015

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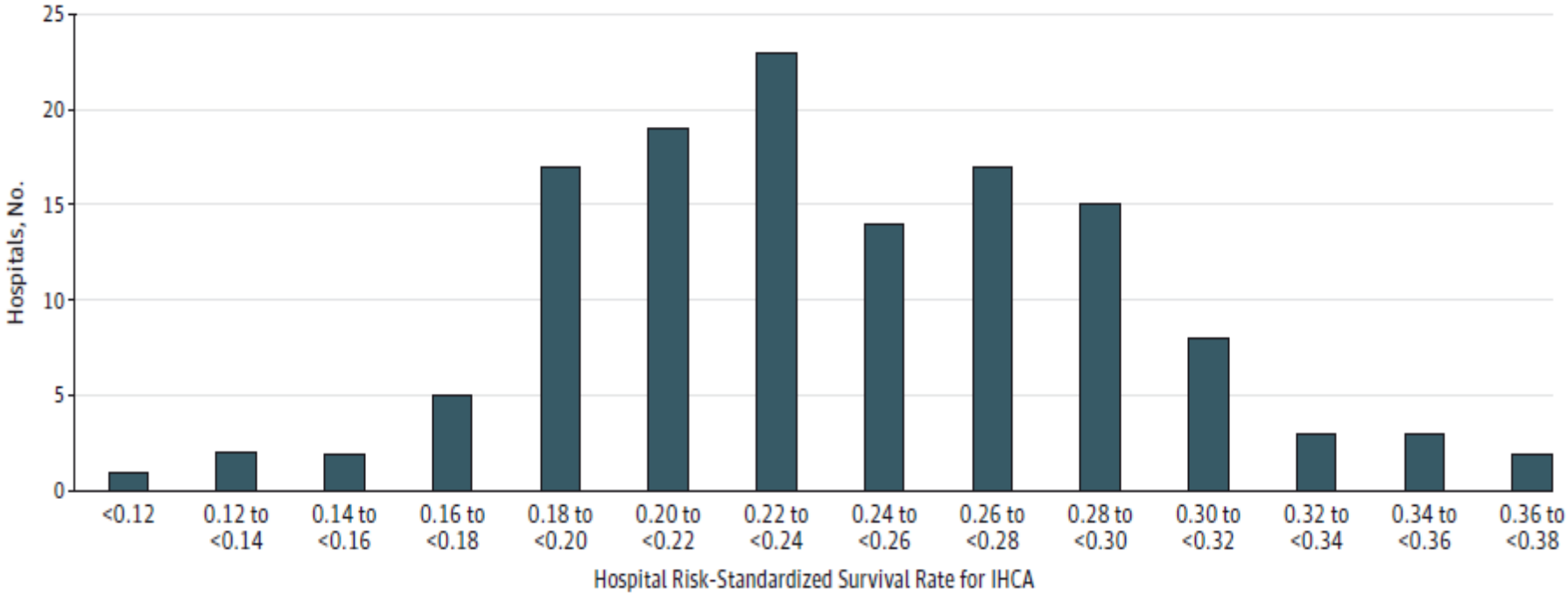
IHCA Risk-Standardized Survival Rate

Figure 1. Distribution of Risk-Standardized Survival Rates for In-Hospital Cardiac Arrest (IHCA) Among Study Hospitals



Chan *et al.*, JAMA Cardiology 2016

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Table 3. Adjusted Associations Between Hospital Factors and Risk-Standardized Survival Rates for In-Hospital Cardiac Arrest

Hospital Resuscitation Strategy or Factor	Adjusted Odds Ratio (95% CI)	*P* Value
Frequency of review of in-hospital cardiac arrest cases		
Less than once quarterly	1 [Reference]	.03
At least once monthly	8.55 (1.79-40.00)	
At least once quarterly	6.85 (1.49-31.30)	
Monitoring for interruptions of chest compressions	2.71 (1.24-5.93)	.01
Adequate resuscitation training at one's hospital (not a barrier or only mild barrier)	3.23 (1.21-8.33)	.02
Monitoring of times to defibrillation	1.89 (0.74-4.83)	.18
Frequency of immediate code debriefing		
Not at all or <10% of all resuscitations	1 [Reference]	.65
10%-49% of all resuscitations	1.19 (0.44-3.23)	
50%-100% of all resuscitations	1.56 (0.61-4.00)	
Presence of intensive care specialist in hospital ICUs at all times	1.84 (0.84-4.00)	.13
Lack of resuscitation champion is a moderate to severe barrier at one's hospital	0.56 (0.21-1.49)	.25

Chan *et al.*, JAMA Cardiology 2016

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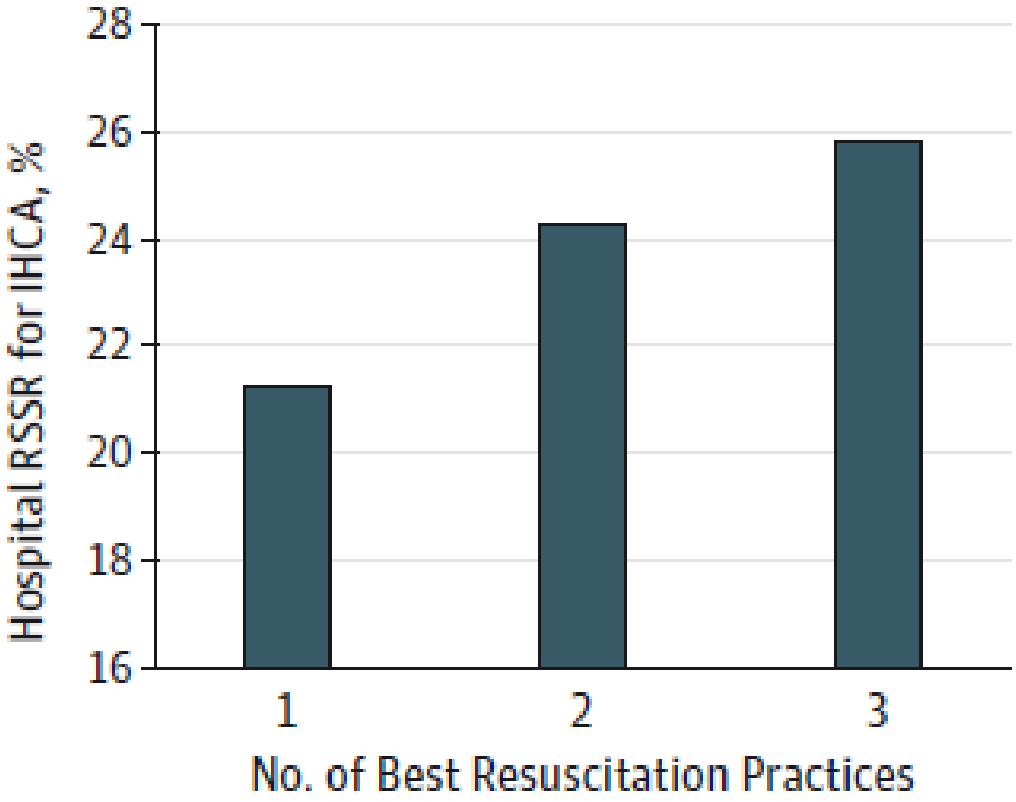
Figure 2. Risk-Standardized Survival Rates (RSSRs) for In-Hospital Cardiac Arrest (IHCA) for Hospitals Using 1, 2, or All 3 Resuscitation Practices



Chan *et al.*, JAMA Cardiology 2016

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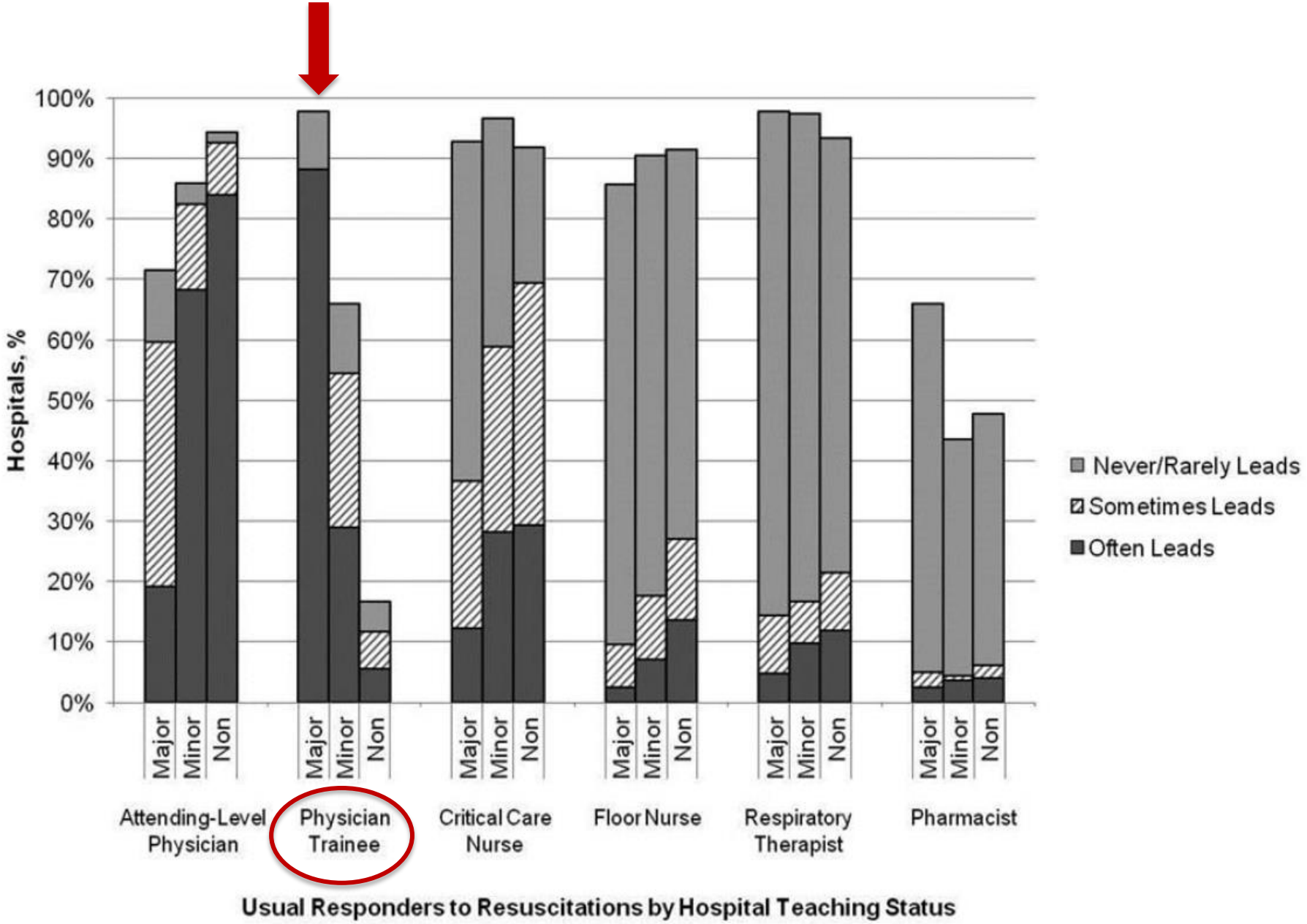
IOM Report 2015

"Resuscitation teams may have limited opportunities to work together over time in emergency situations, frequently coming together on an *ad hoc* basis to respond to an IHCA. This approach is innately more stressful and requires greater levels of leadership and teamwork in order to successfully deliver resuscitation care."

Graham *et al.* IOM Report 2015



Edelson *et al.*, J Hosp Med 2014

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Residents feel unprepared and unsupervised as leaders of cardiac arrest teams in teaching hospitals: A survey of internal medicine residents*

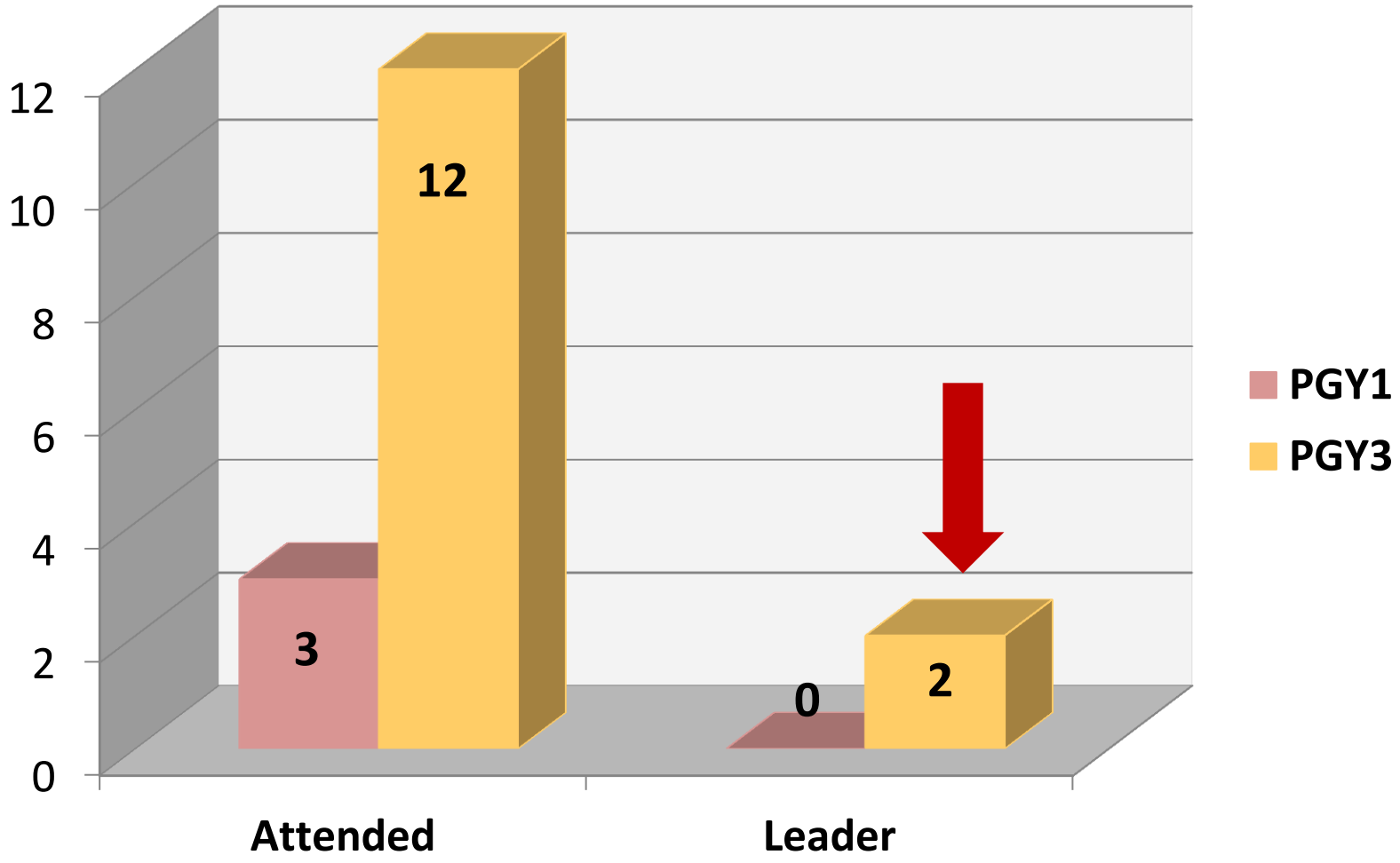
- 49.3% felt inadequately trained to lead team
- 50.9% felt ACLS did not provide leadership training

Hayes *et al.*, Crit Care Med 2007

Housestaff experience with IHCA:

Single-center, cross-sectional survey Dec 2015

Median number of IHCA **attended** and **led**



L Brown, Unpublished data

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Code BLUE Team

At University of Louisville Hospital

- Inter-professional, simulation-enhanced, team-based monthly curriculum[1]
- Participants (from the same unit):
  - MD trainees -- RT
  - PharmD -- ICU RN

1. Approved by University of Louisville IRB #14.1211
Supported by Innovations Seed grant from Alliance for Academic Internal Medicine

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Code BLUE Team

At University of Louisville Hospital

- 90-minute session
  1. VT/VF arrest
  2. Debrief
  3. Repeat identical scenario
- Mock Code

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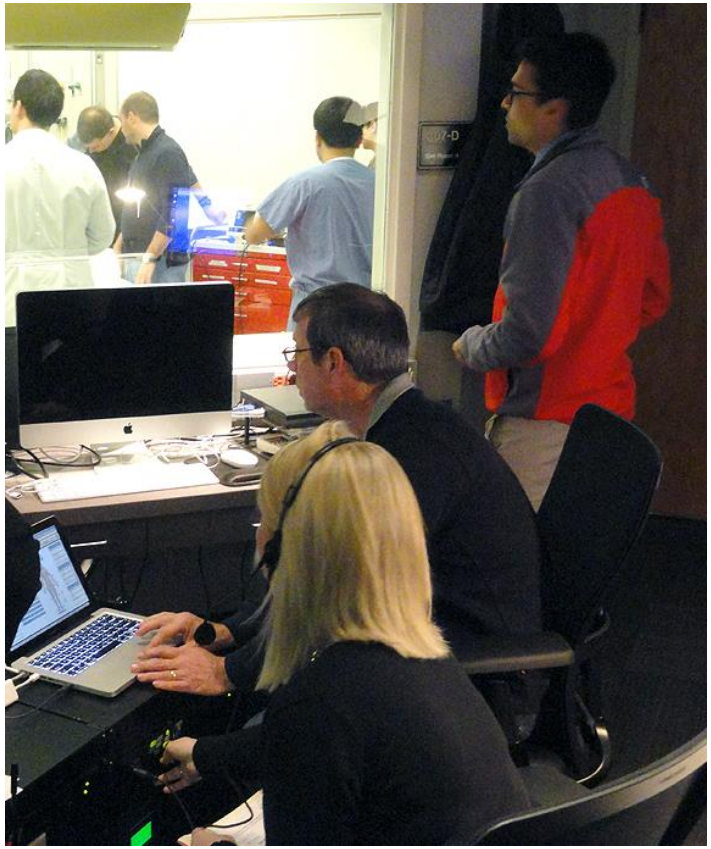
Code BLUE Team

At University of Louisville Hospital

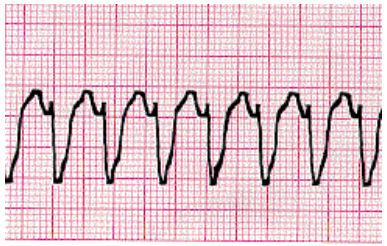


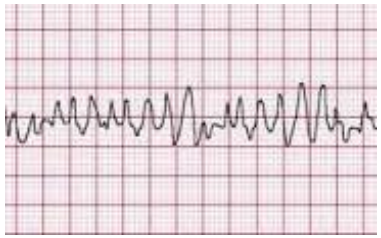
Code BLUE Team

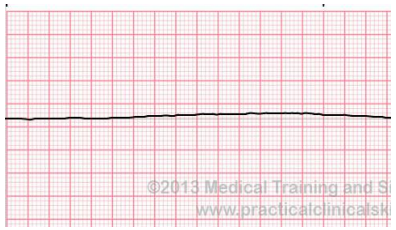
At University of Louisville Hospital

5 min | 2.5 min | 7 min

Stable VT → **Pulseless VT** → **VF** → **Asystole**







Successful resuscitation requires:

- ✓2 minutes of effective ventilation
- ✓2 minutes of effective CPR
- ✓2 defibrillations
- ✓1 dose of vasoconstrictor (vasopressin or epi)
- ✓1 dose amiodarone (code dose)

Adapted with permission from Jules Jung, MD, Johns Hopkins School of Medicine Department of Emergency Medicine

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Skill **Key: A = Done Correctly B = Done Incorrectly C = Not Done**				
Recognize pulseless patient within 10 seconds	A	B	C	n/a
Check responsiveness	A	B	C	n/a
Confirm patient code status	A	B	C	n/a
Get Help – Call Code	A	B	C	n/a
Assign roles – verbal or understood	A	B	C	n/a
Call for defibrillator	A	B	C	n/a
Initiate CPR within 10 seconds of recognizing pulseless	A	B	C	n/a
Adequate rate >100/min	A	B	C	n/a
Give oxygen.	A	B	C	n/a
Give respirations at rate of 8-10/min via bag-mask	A	B	C	n/a
Attach monitor/defibrillator and plug in/turn on	A	B	C	n/a
Check/Identify rhythm on monitor <10 sec	A	B	C	n/a
Charge while continuing CPR	A	B	C	n/a
Clear	A	B	C	n/a
Defibrillate #1 *as soon as defibrillator is attached to patient and shockable rhythm identified*	A	B	C	n/a
Immediately resume CPR	A	B	C	n/a
CPR 2 minutes	A	B	C	n/a
Adequate rate >100/min	A	B	C	n/a
Pulse/rhythm check <10 sec	A	B	C	n/a
Charge while continuing CPR	A	B	C	n/a
Clear	A	B	C	n/a
Defibrillate #2	A	B	C	n/a
Search 5H/5T	A	B	C	n/a
Change compressor every 2 minutes OR as needed	A	B	C	n/a
Immediately resume CPR	A	B	C	n/a
CPR 2 minutes – do not stop for meds	A	B	C	n/a
Adequate rate >100/min	A	B	C	n/a
Epinephrine 1mg IV push, repeat every 3-5 minutes OR Vasopressin 40 U IV single dose to replace 1st or 2nd dose of Epi	A	B	C	n/a

Adapted from Edelson *et al.*, MedEd Portal

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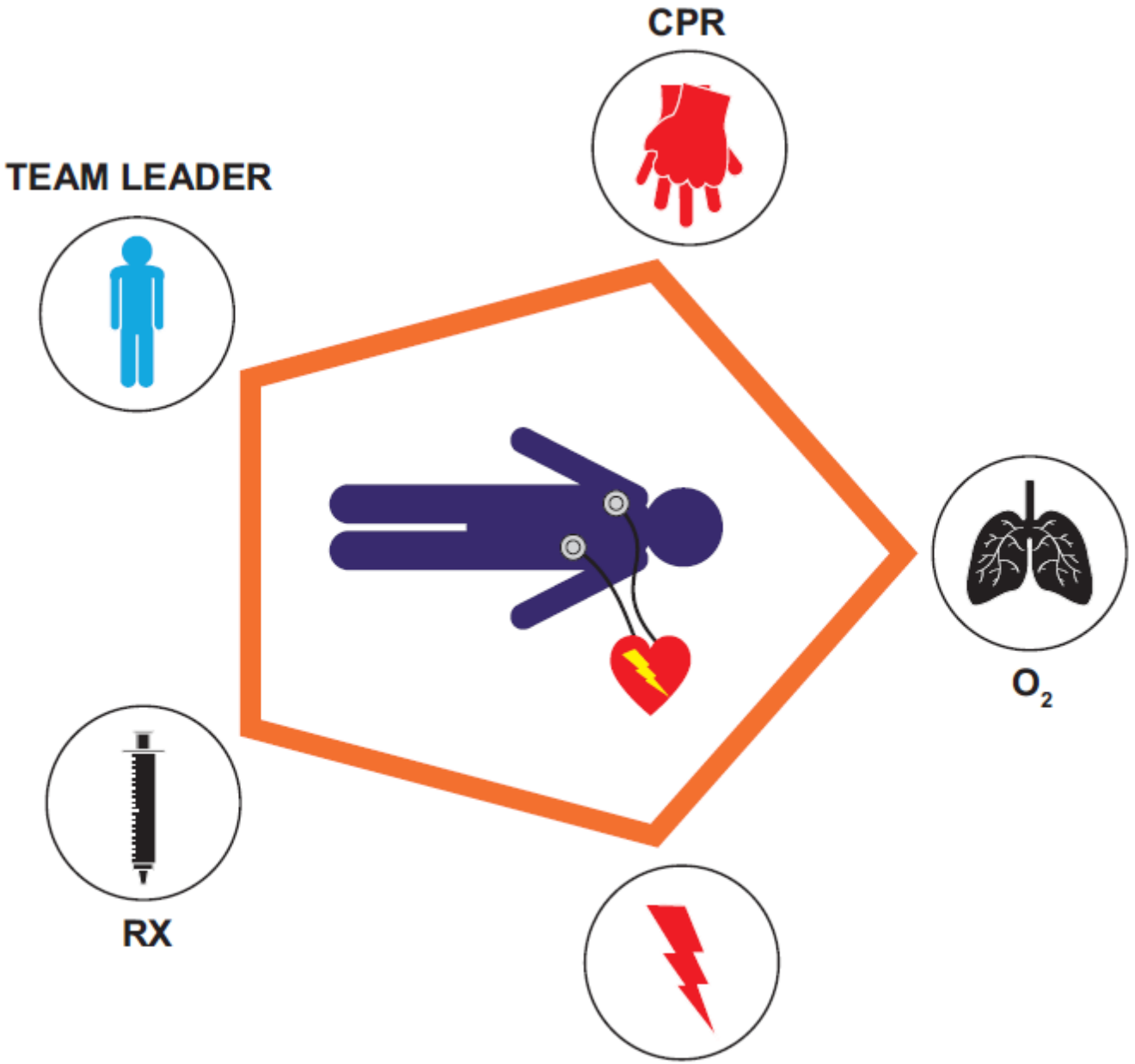

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Code BLUE Team

At University of Louisville Hospital

OUTCOMES

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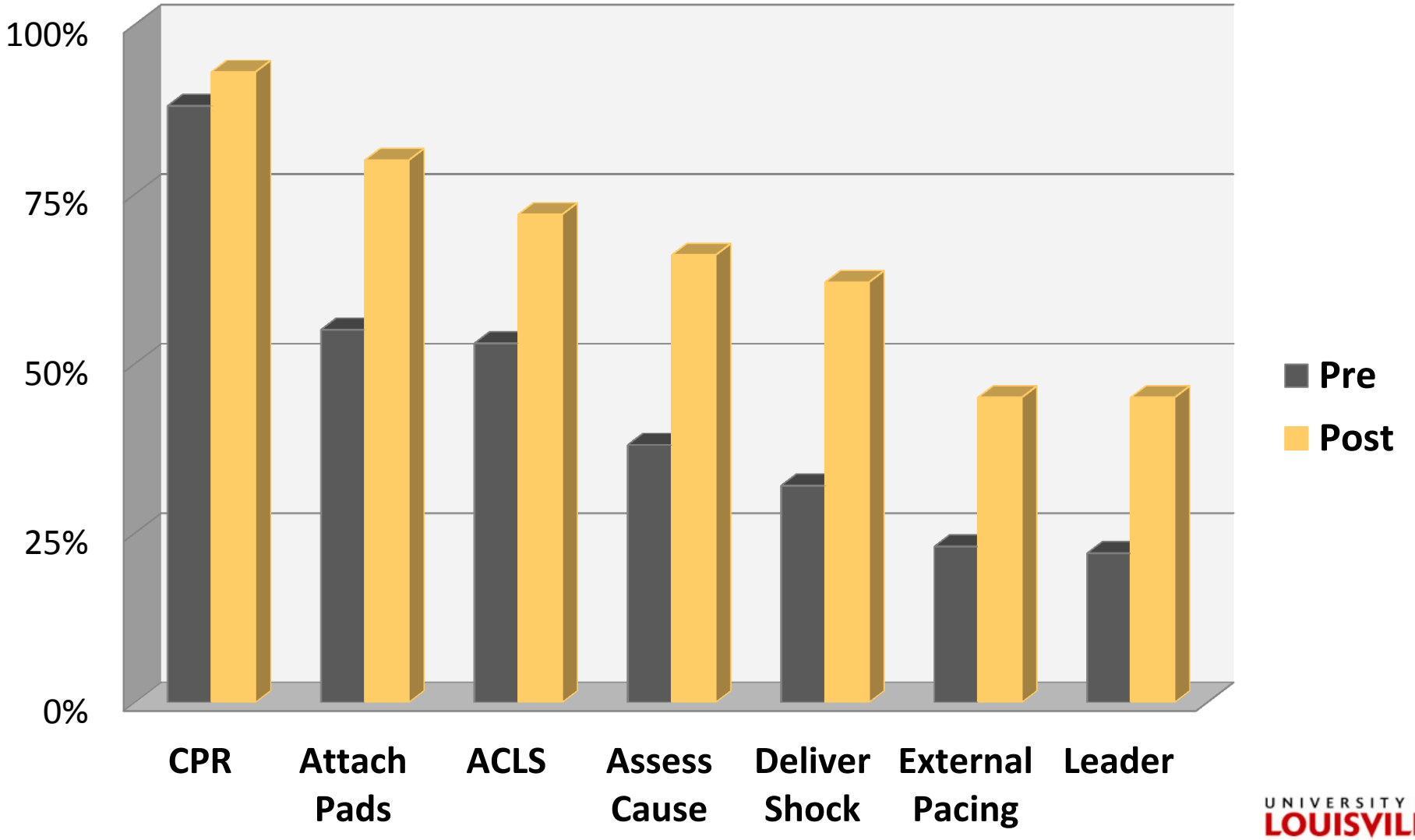
% of MD Trainees Reporting Comfort with Resuscitation Skills



L Brown, Unpublished data

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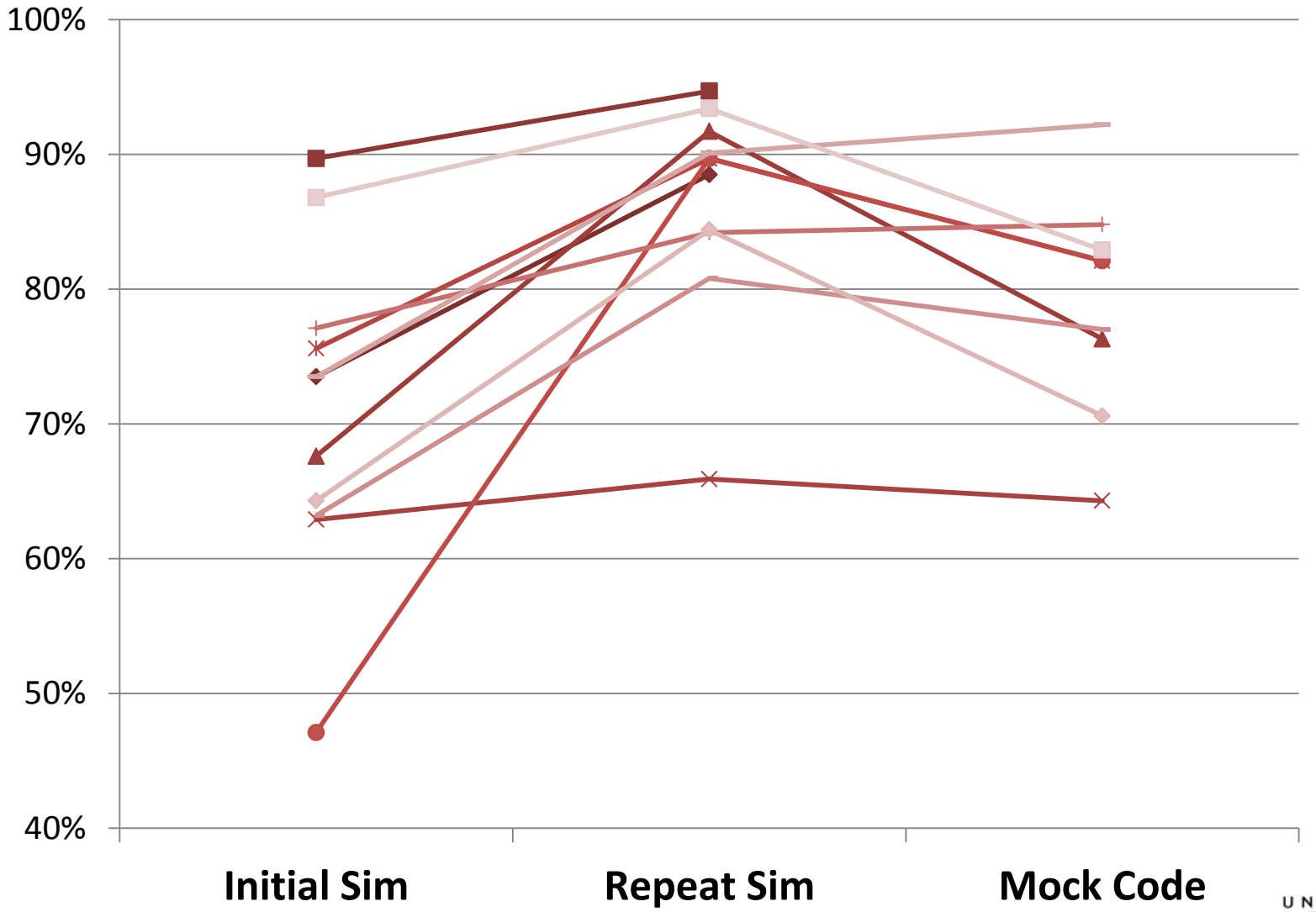
ACLS Adherence Scores



L Brown, Unpublished data

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Observations

- MD struggle with defibrillator
- Most groups did a full 2-min round of CPR prior to defibrillation
- Obsession with epi
- Unfamiliar with post-arrest care for VT/VF
- Presence of even 1 well-trained or experienced provider changes the dynamic

Conclusions

- There are too many preventable deaths from cardiac arrest (both in- and out-of-hospital).
- We *know* best practices, but there is wide variability with real-world implementation.
- Educational efforts can strategically target vital links in the chain of survival: bystander CPR for OHCA, and high-quality ACLS team training and performance for IHCA.
- Improving outcomes even 1% translates into thousands of lives saved.

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Thank You

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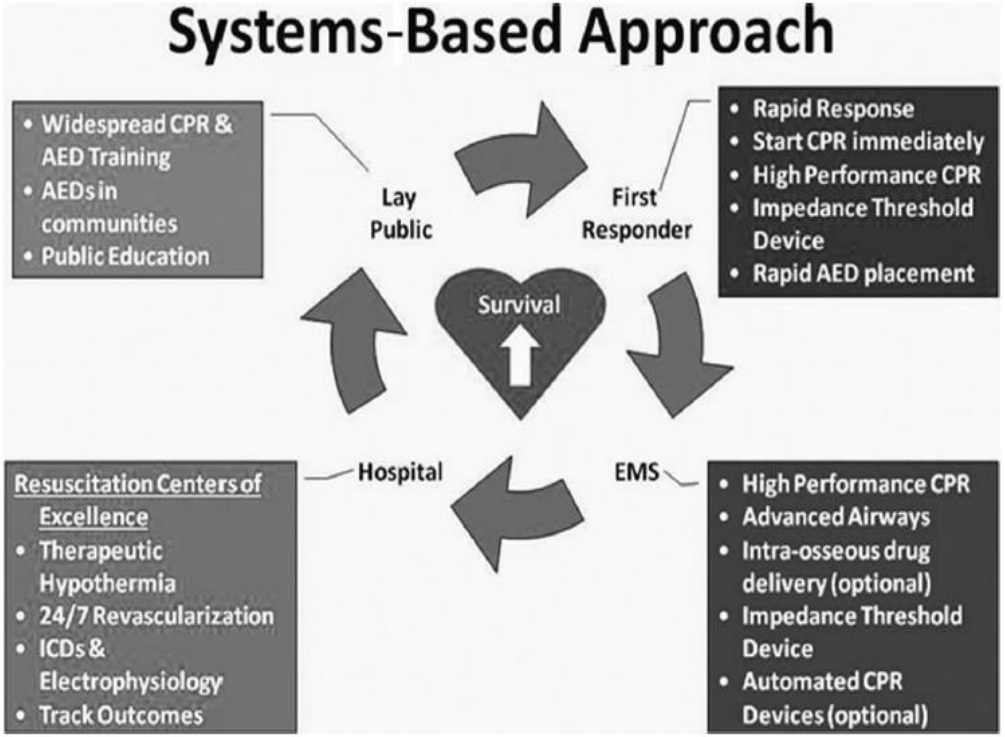

Outcome	Period	
	Control (n = 106)	Intervention (n = 247)
Return of spontaneous circulation prehospital	40 (38%)	116 (47%)
Admitted to intensive care unit	37 (35%)	95 (38%)
Discharged alive from hospital	9 (8.5%)	48 (19%)
Cerebral performance category score	1.63 ± 0.52	1.38 ± 0.70

Lick *et al.*, Crit Care Med 2011

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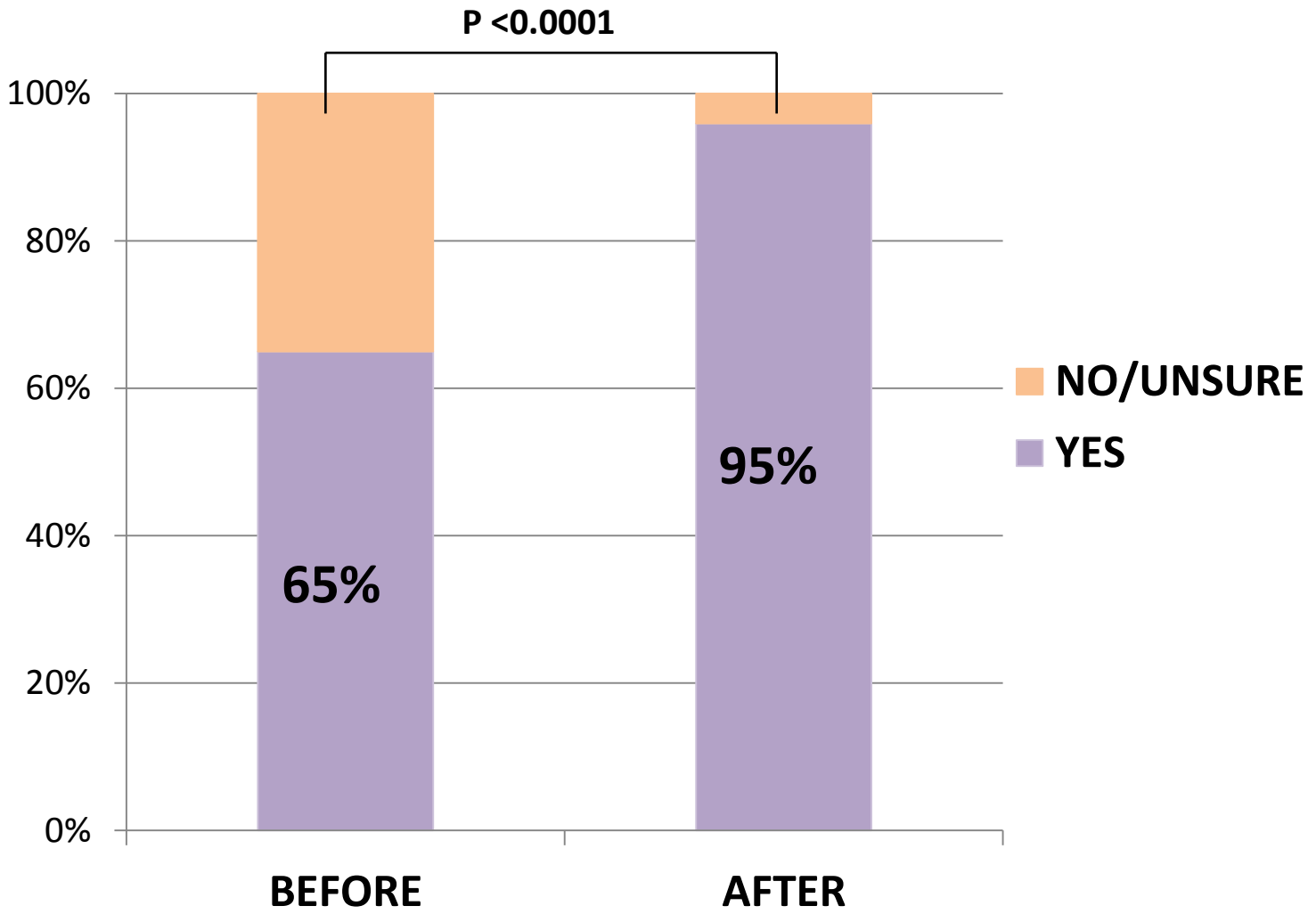
Q: Are you willing to perform CPR?



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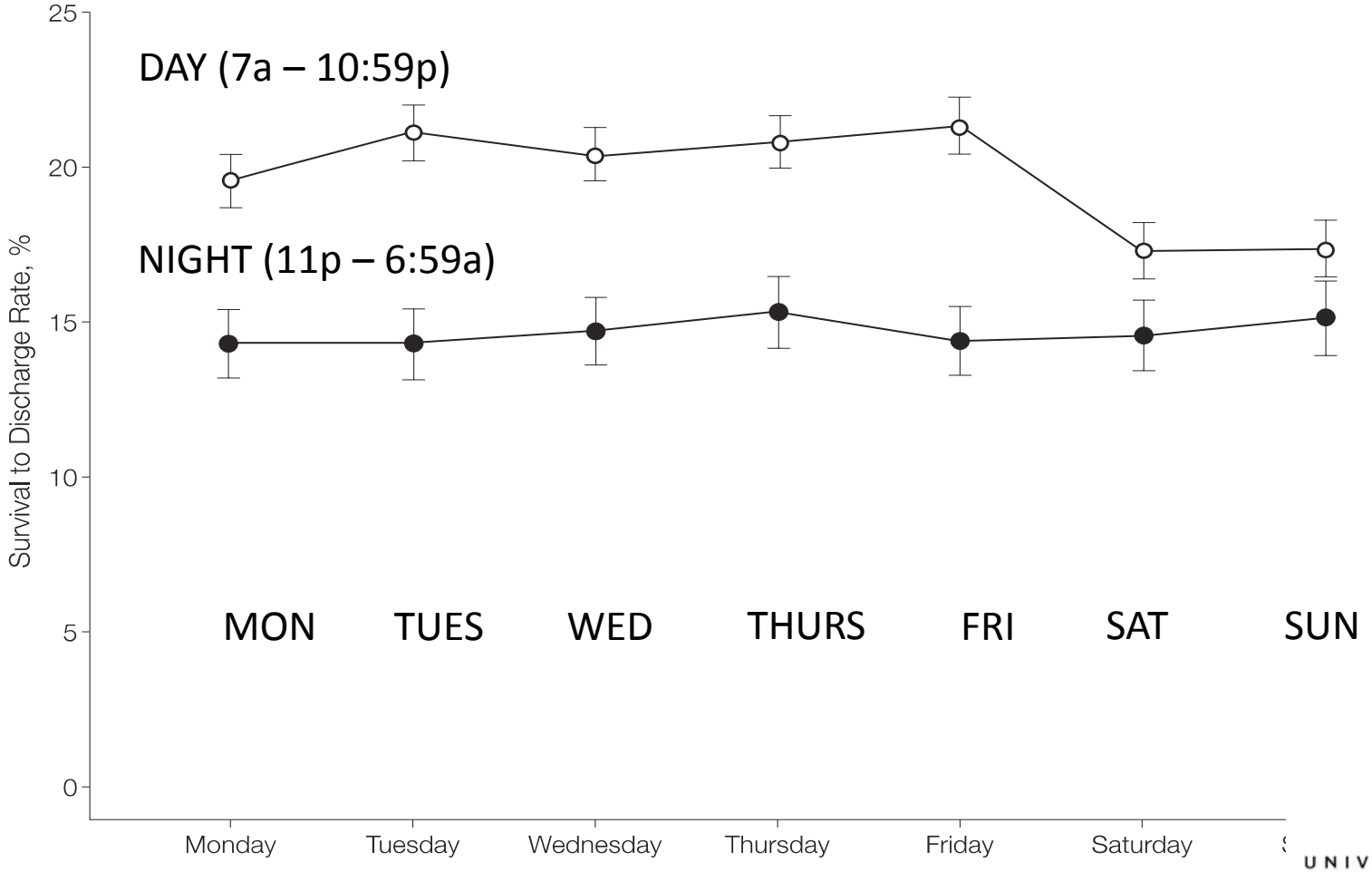
Survival From In-Hospital Cardiac Arrest During Nights and Weekends

Figure 3. Survival to Discharge Rate and Total Arrests by Time Category and Day of Week



Peberdy *et al.*, JAMA 2008

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