got access?

Pediatric Trauma Care in the United States

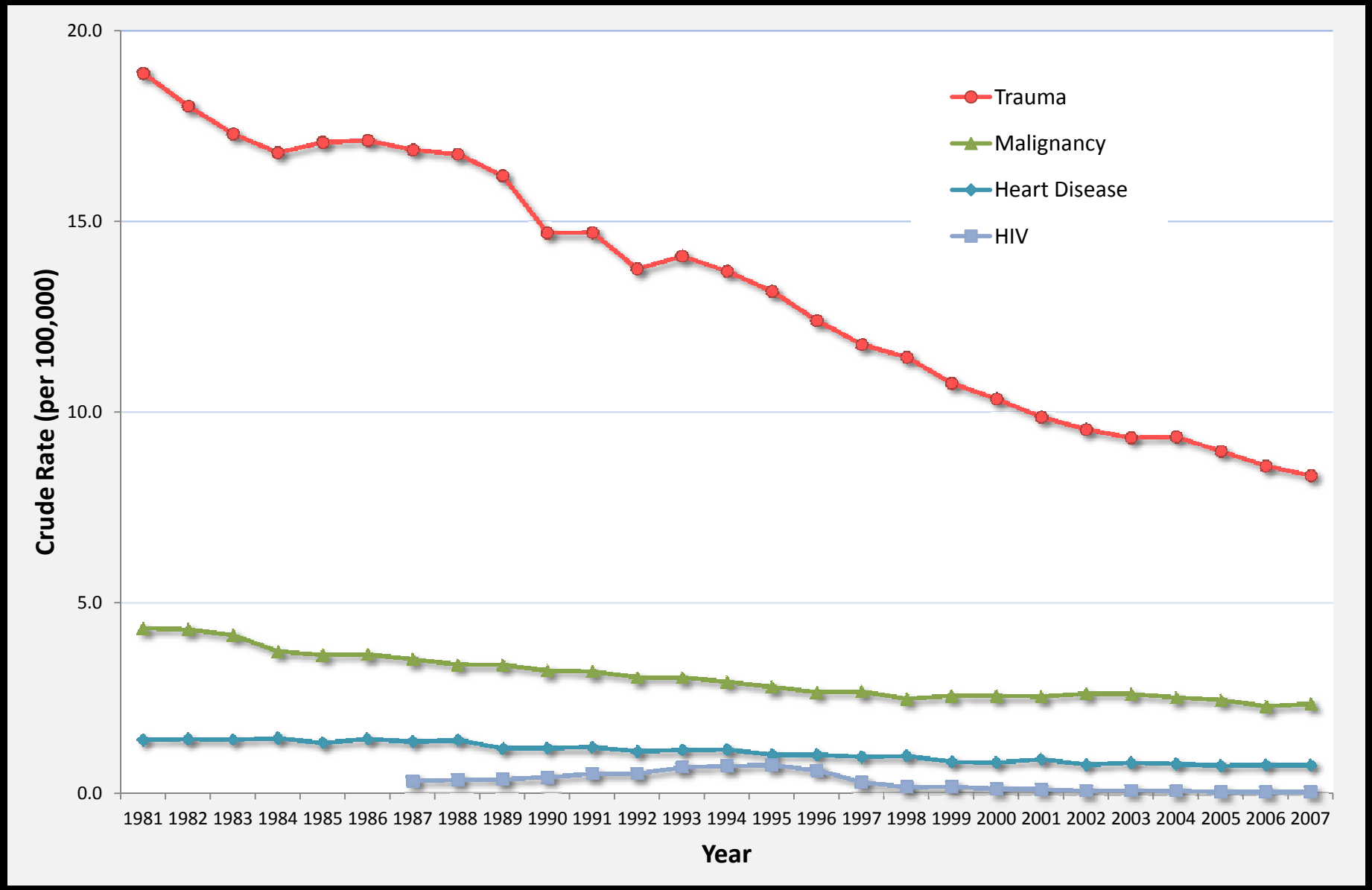
Michael L. Nance, MD
Templeton Chair in Pediatric Trauma
Director, Pediatric Trauma Program
Children's Hospital of Philadelphia

- One in five children (14 million) injured each year
- 25% of trauma patients are pediatric
- 9 million ED visits
- 250,000 admissions
- 17,000 deaths
- $50.5 billion annual costs
  - (Iraq 2003-$53 billion)

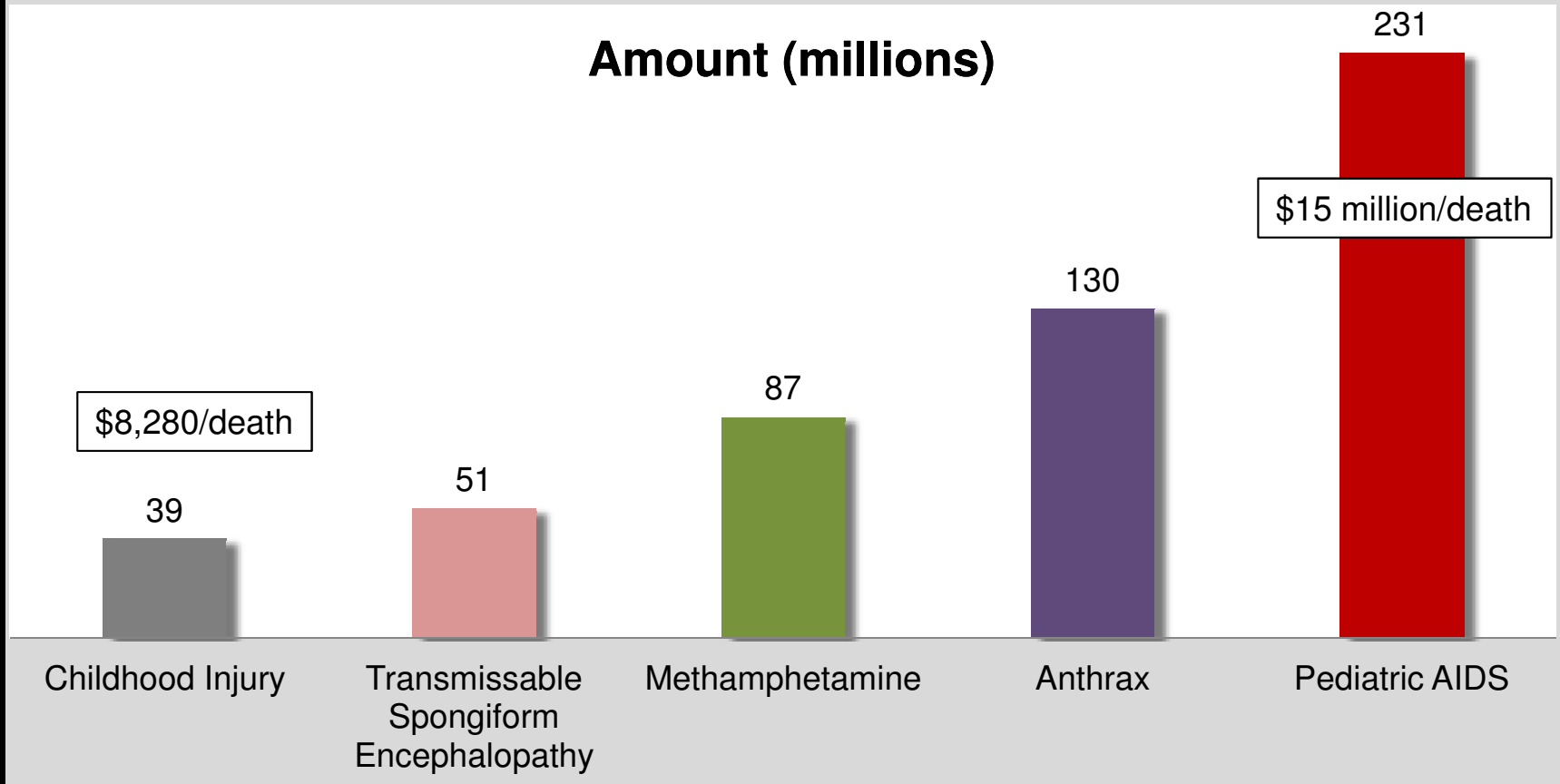
Why do we care about trauma and kids?

"If a disease were killing our children in the proportions that injuries are, people would be outraged and demand that this killer be stopped.“

--C. Everett Koop, M.D.


20.0
15.0
10.0
5.0
0.0
Crude Rate (per 100,000)
Trauma
Malignancy
Heart Disease
HIV
1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
Year

NIH spending on select diseases 2010

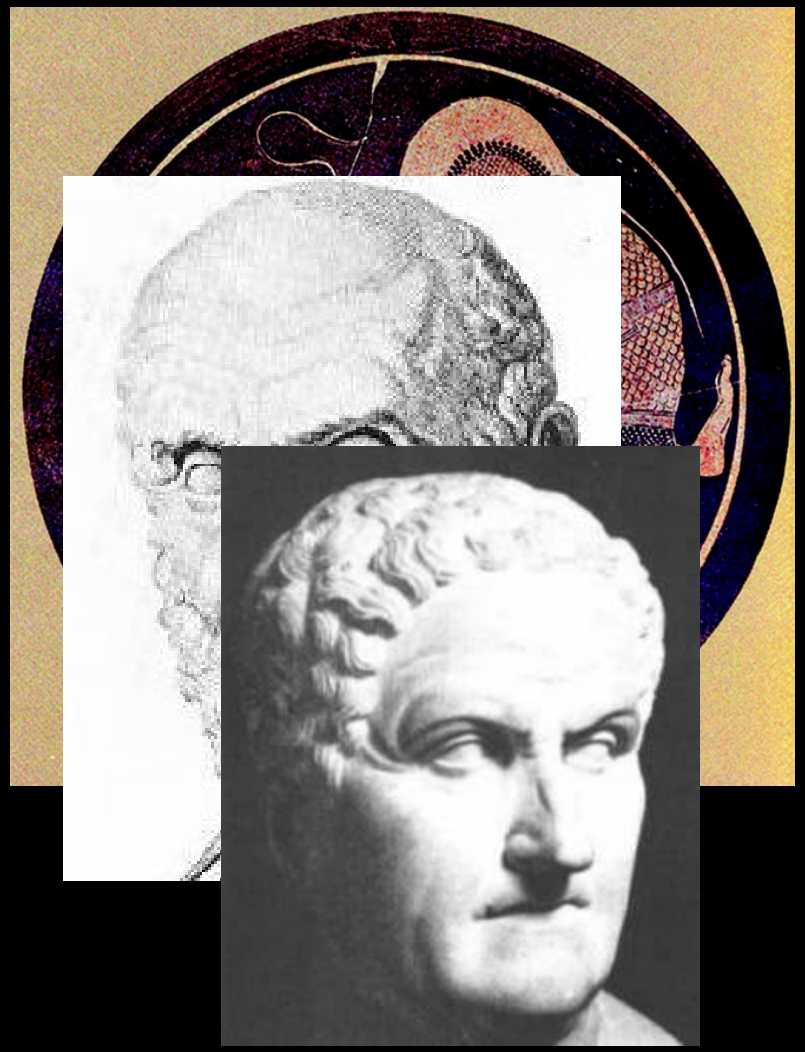


2007 mortality data, 2010 NIH data

History of Trauma Care

(Brief)

- Achilles (Illiad, 800 B.C.) caring for the wound of his cousin in the Trojan War
- Hippocrates (460–377 B.C)-npo for abdominal wounds, traction for fractures
- Galen 130–200 A.D. recognized by Marcus Aurelius for his care of the gladiators



History of Trauma Care

Amboise Parè (c. 1510-1590)

- Official surgeon to kings Henry II, Francis II, Charles IX and Henry III
- Leader in development of battlefield medicine
- Observed antiseptic properties of turpentine
- Introduced ligature of arteries rather than cauterization

History of Trauma Care

Dominique Larrey (1766-1842)

- Surgeon in the Army of Napoleon
- Pioneered triage
- Considered first military surg
- Credited with 200 amputations at the Battle of Borodino (1 every 7.2 minutes). Larrey could amputate at the hip joint in 15 seconds and the shoulder in 1 1/2 seconds
- Developed the "flying Ambulance"

Dominique-Jean Larrey (1766-1842)[1]

History of Trauma Care

Florence Nightingale, 1820-1910

- Active in the Crimean War (1854-1856)
- Worked with 37 other nurses to coordinate medical relief activities, emphasized sanitation and hygiene
- Striking reduction of death from disease established new standards for military hospitals
- Benefits of antisepsis (Lister) not used formally until Spanish-American war (1898)

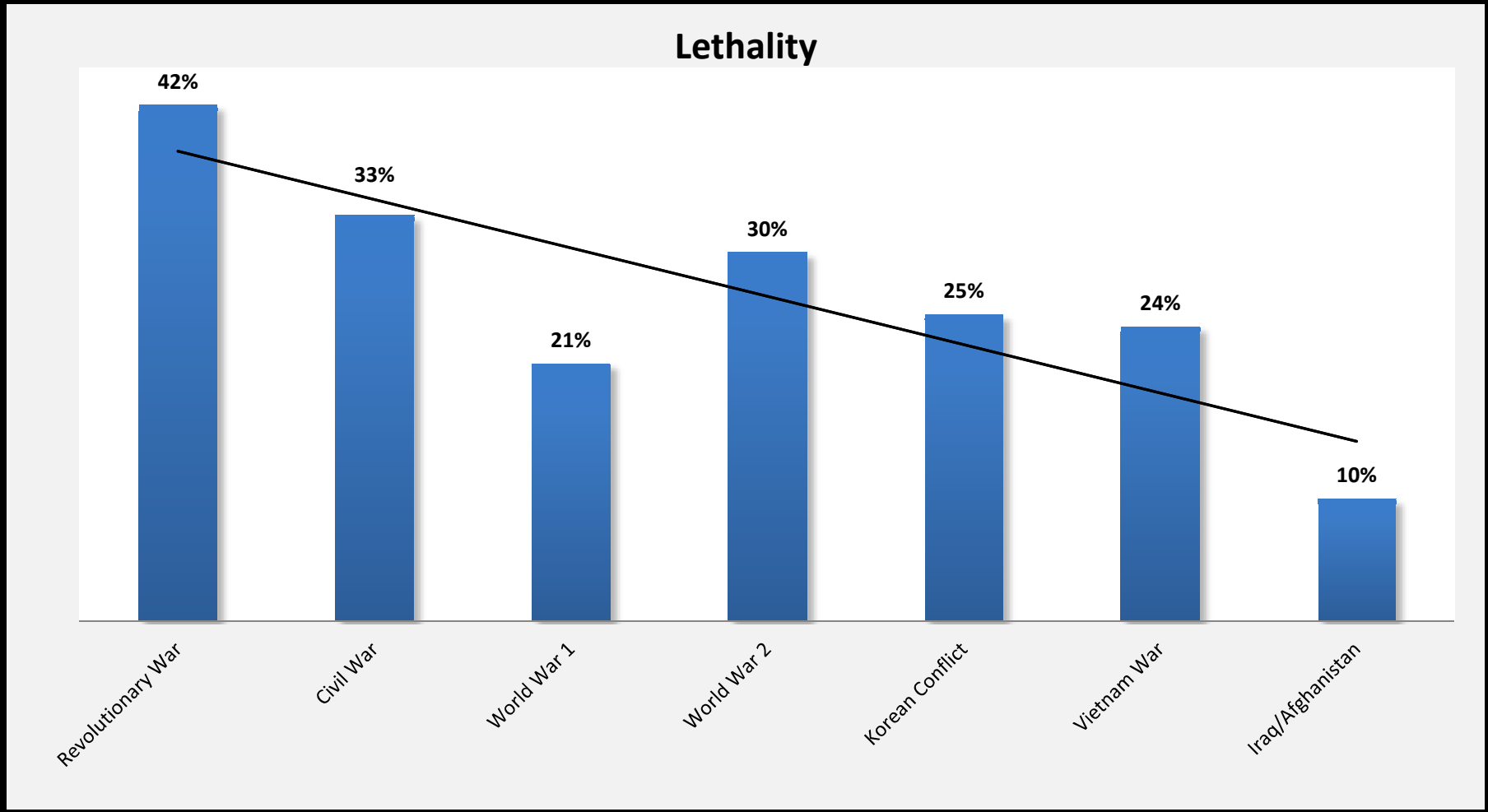
Transportation and Trauma Care

History of Trauma Care

Forward Surgical Care

- Renal failure recognized as frequent cause of death or morbidity (shock)
- Korean conflict moved hospital closer to patient (M.A.S.H.)
- Vietnam Conflict saw increased use of helicopter transport (minutes)
- Operation Iraqi Freedom (I and II) saw implementation of the Forward Resuscitative Surgery System
- Small medical teams (6-8 persons) deployed in the battle space

History of Trauma Care in the US



Time and access to care matter

Civilian Trauma Systems

- Organized trauma systems began to take shape in the1960s and 1970s.
- National Highway Safety Act of 1966
- Emergency Medical Services Act of 1973.

- State trauma systems were developed in Maryland and Illinois
- The American College of Surgeons Committee on Trauma (ACSCOT) in 1976 published ‘Optimal Care for the Injured Patient’
- ATLS course unveiled, 1978 with advocacy of “Golden Hour”
- Institute of Medicine recognizes Trauma System as a model of health care delivery
- Trauma systems regulated at the state level with no national central accrediting body

- Modern pediatric trauma care took several more decades to evolve
- Emergency Medical Services for Children (EMS-C) program created in 1984
- Meant to ensure optimal integration of ill and injured children into EMS systems
- IOM (2006) and Healthy People 2010 recognized fragmentation and variation in delivery of pediatric emergency care

Recommended coordination, regionalization, and accountability

"…ensure that each patient receives the most appropriate care, at the optimal location, with the minimum delay."

Emergency Care for Children: Growing Pains, Institute of Medicine, 2006

Do Trauma centers improve outcome?

- Methodologically challenging question
- Most studies would suggest Trauma Centers beneficial
- Panel studies and registry based studies--yes
- Registry based studies demonstrate about 15% reduction in mortality
- Impact of establishing trauma center in region—15-20% reduction

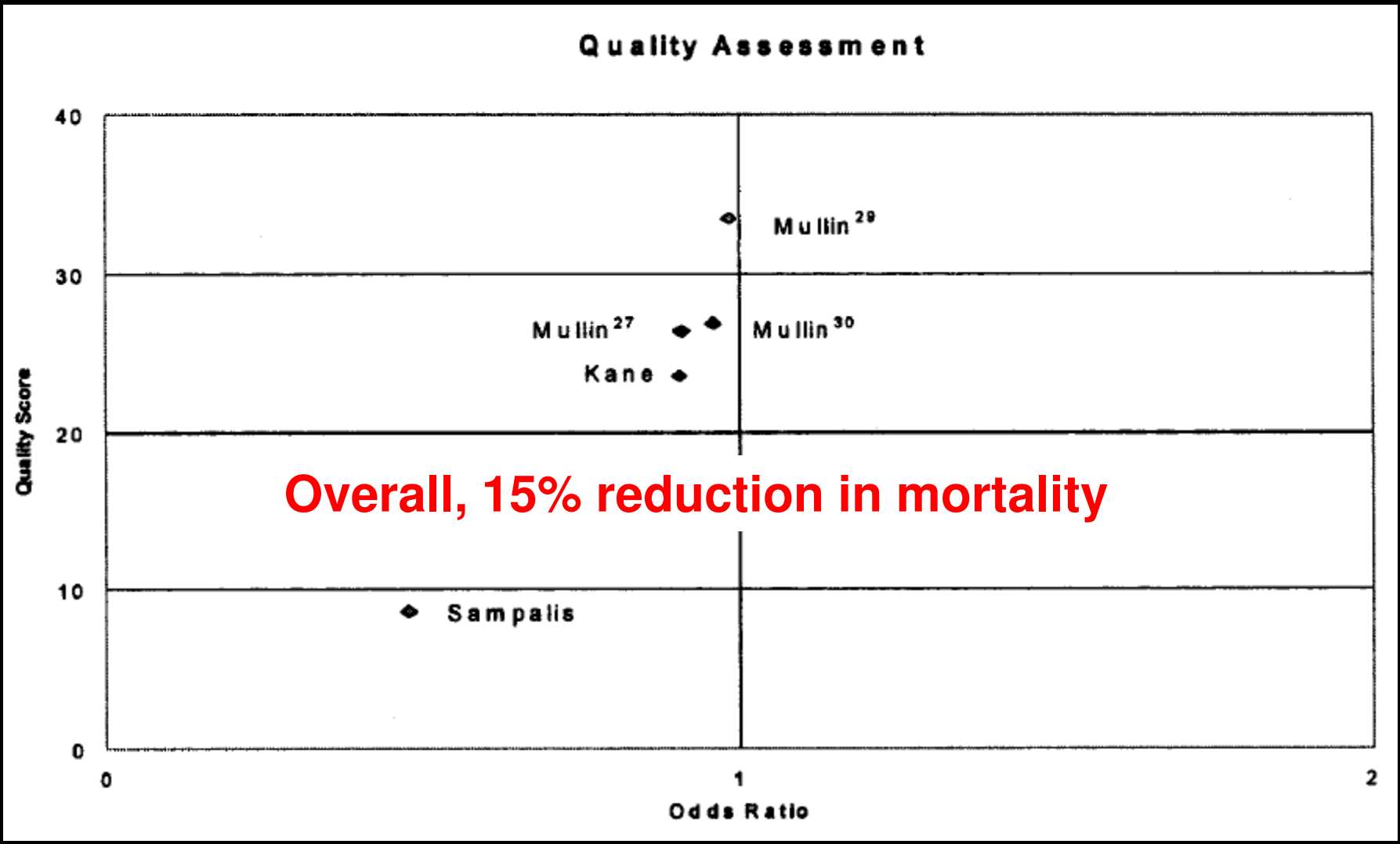
The Journal of TRAUMA® Injury, Infection, and Critical Care

A Systematic Review and Meta-Analysis Comparing Outcome of Severely Injured Patients Treated in Trauma Centers Following the Establishment of Trauma Systems

Brian Celso, PhD, Joseph Tepas, MD, Barbara Langland-Orban, PhD, Etienne Pracht, PhD, Linda Papa, MD, Lawrence Lottenberg, MD, and Lewis Flint, MD

benefit following trauma center

J Trauma 2006


Quality Assessment
40
30
20
10
0
Quality Score
Mullin 29
Mullin 27
Mullin 30
Kane
Sampalis
Overall, 15% reduction in mortality
0
1
2
Odds Ratio

A National Evaluation of the Effect of Trauma-Center Care on Mortality

Ellen J. MacKenzie, Ph.D., Frederick P. Rivara, M.D., M.P.H., Gregory J. Jurkovich, M.D., Avery B. Nathens, M.D., Ph.D., Katherine P. Frey, M.P.H., Brian L. Egleston, M.P.P., David S. Salkever, Ph.D., and Daniel O. Scharfstein, Sc.D.

- Most definitive study to date, NSCOT
- 20% risk reduction for patients treated at a TC
- Looked at outcome of more than 18,000 patients treated at TCs (18) or non-TCs (34) in 14 states in the US
- Risk reduction limited to patients <55 yrs
- Risk reduction more pronounced in higher AIS and ISS
- All patients treated during the same time period

Mackenzie, et al NEJM 2006

What Price Commitment: What Benefit? The Cost of a Saved Life in a Developing Level I Trauma Center

Michael F. Rotondo, MD, Michael R. Bard, MD, Scott G. Sagraves, MD, Eric A. Toschlog, MD, Paul J. Schenarts, MD, Claudia E. Goettler, MD, Mark A. Newell, MD, and Matthew J. Robertson, MBA

TABLE 9. Total Number of Lives Saved

ISS	Age (yr)	Saved Lives
	18–54	65*
Total		173*/207

- **Demonstrated 173 lives saved at a cost of $87,000/life over pre-TC expenditures**

Rotondo, J Trauma 2009

ORIGINAL ARTICLE

The Value of Trauma Center Care

Ellen J. MacKenzie, PhD, Sharada Weir, PhD, Frederick P. Rivara, MD, MPH, Gregory J. Jurkovich, MD, Avery B. Nathens, MD, PhD, MPH, Weiwei Wang, PhD, Daniel O. Scharfstein, PhD, and David S. Salkever, PhD

- Secondary analysis of NSCOT data
- Cost effectiveness estimated as difference in cost from TC vs. non TC divided by life years gained (and lives saved)
- Added cost per treatment was $36,319 per life year gained ($790,931 per life)
- Cost effectiveness more favorable for younger patients and more severe injuries

Mackenzie, J Trauma, 2010

ORIGINAL ARTICLE

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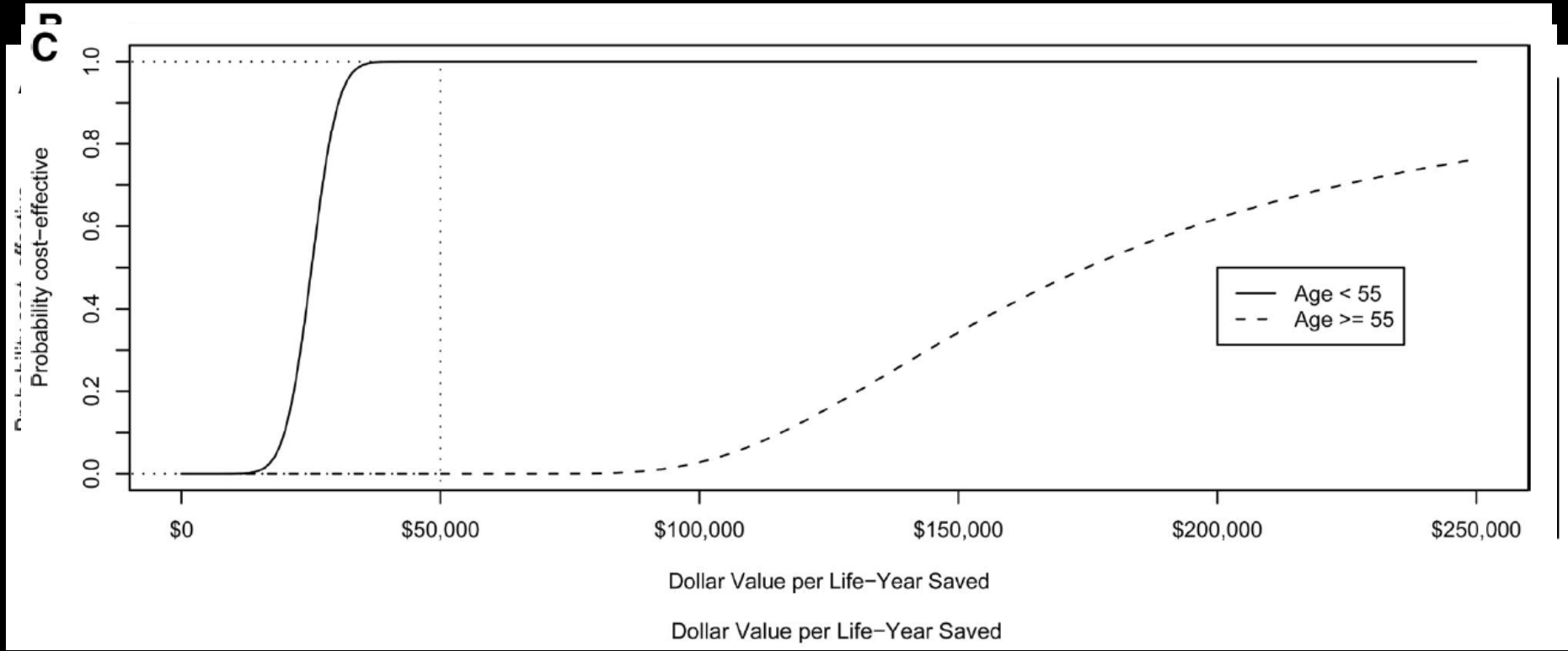
Ellen J. MacKenzie, PhD, Sharada Weir, PhD, Frederick P. Rivara, MD, MPH, Gregory J. Jurkovich, MD, Avery B. Nathens, MD, PhD, MPH, Weiwei Wang, PhD, Daniel O. Scharfstein, PhD, and David S. Salkever, PhD



Mackenzie, J Trauma, 2010

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The Value of Trauma Center Care

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TABLE 5. Cost-Effectiveness Ratios for Selected Life-Saving Interventions

Intervention	Comparator	Target Population	Incremental Cost-Effectiveness Ratios*
Prophylactic implantation of an implantable cardioverter defibrillator (ICD)[35]	Conventional treatment	Patients at risk of sudden death because of left ventricular systolic dysfunction	$25–51 per QALY added (in thousands of US $2005)
Administration of drotrecogin alfa (activated)[34]	Usual care	Adults with severe sepsis	$34–70 per QALY added (in thousands of US $2003)
Mechanical ventilation and continued aggressive care[34]	No mechanical ventilation or mechanical ventilation withheld	Adults with acute respiratory failure	$33–147 per QALY added (in thousands of US $2003)
Public access defibrillation (PAD)[33]	Standard emergency medical service agency	Persons in cardiac arrest	$27–57 per QALY added (in thousands of US $2003)
Reducing response time for cardiac arrest[33]	Existing emergency medical service agency	Persons in cardiac arrest	$40–368 per QALY added (in thousands of US $2003)
Renal dialysis, current practice[32]	Next least costly strategy	Persons with end-stage renal disease	Average of $129 per QALY added (in thousands of US $2003)

* Ranges in CERs reflect differences in specifics of the intervention, comparator, target population, and methods for estimating costs and effectiveness across studies.

Mackenzie, J Trauma, 2010

There appears to be an outcome (in selected groups) and cost benefit to TC care

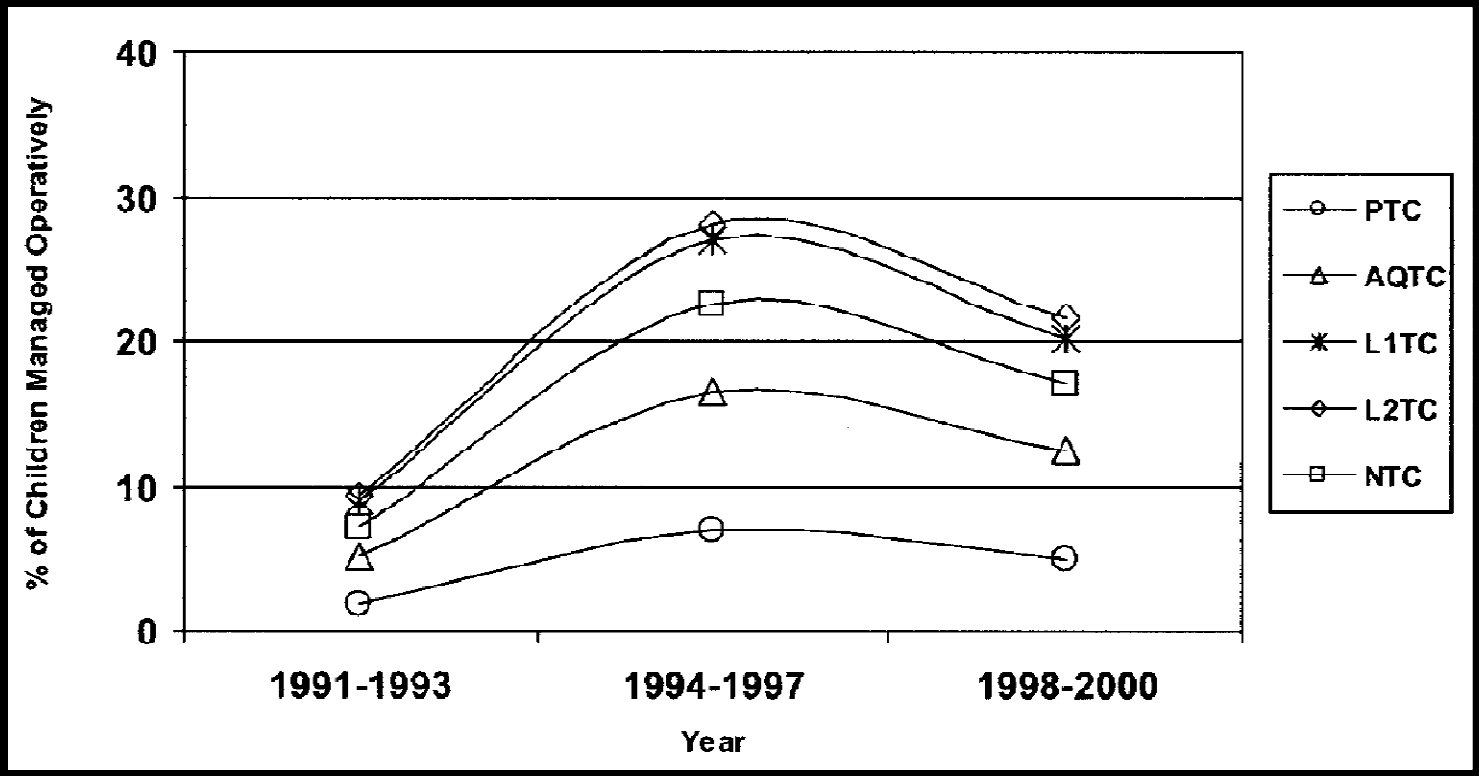
But…

Majority of these studies excluded children

Is outcome improved for children treated at a (pediatric) trauma center?

Trends in Operative Management of Pediatric Splenic Injury in a Regional Trauma System

Daniela H. Davis, MD, MSCE*‡; A. Russell Localio, JD, MS‡; Perry W. Stafford, MD§; Mark A. Helfaer, MD‖; and Dennis R. Durbin, MD, MSCE‡¶



Davis, Pediatr 2005

The Journal of TRAUMA® Injury, Infection, and Critical Care

Variation in the Management of Pediatric Splenic Injuries in New England

David P. Mooney, MD, and Peter W. Forbes, MA

Table 7 Isolated Splenic Injuries and Patients with Multiple Injuries, Adjusted Operative Management Rates, PSs vs. NPSs

	Isolated Splenic Injury			Multiple Injuries			Total		
	PSs	NPSs	*p* Value	PSs	NPSs	*p* Value	PSs	NPSs	*p* Value
%Op	11	30	<0.0001	27	35	0.004	16	32	<0.0001

Operative rates after adjustment through direct standardization.

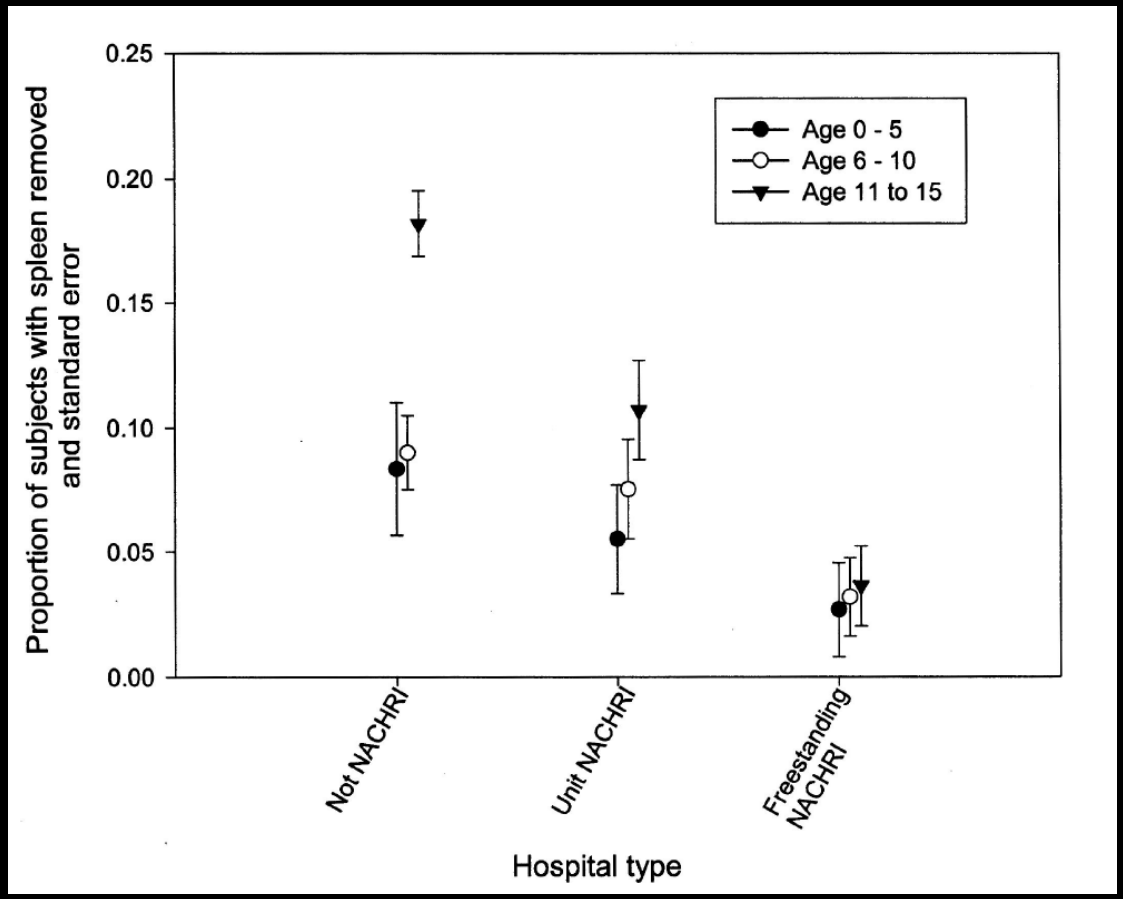
Multiple injuries, any nonsplenic AIS score of 2 or greater; PSs, pediatric surgeons; NPSs, nonpediatric surgeons; %Op, the percentage of children with a splenic operation recorded.

Mooney, J Trauma 2004

The Journal of **TRAUMA**® *Injury, Infection, and Critical Care*

Variation in the Management of Pediatric Splenic Injuries in the United States

David Patrick Mooney, MD, David H. Rothstein, MD, and Peter W. Forbes, MA



Mooney, J Trauma 2006

Pediatric Trauma Centers provide different care…

…but is it better care?

The Journal of TRAUMA® Injury, Infection, and Critical Care

Impact of Pediatric Trauma Centers on Mortality in a Statewide System

Douglas A. Potoka, MD, Laura C. Schall, MS, Mary J. Gardner, RN, Perry W. Stafford, MD, Andrew B. Peitzman, MD, and Henri R. Ford, MD

Table 4 Mortality Rate by Trauma Center, Injury Severity, and Injury Type

	PTC (%)	ATC AQ (%)	ATC I (%)	ATC II (%)
Overall	187/5189 (3.6)	156/3636 (4.3) $p = 0.1$	97/1207 (8.0) $p = 0.001$	157/3319 (4.7) $p = 0.01$
ISS < 15	39/3945 (0.99)	16/2503 (0.64) $p = 0.137$	17/868 (1.96) $p = 0.016$	19/2466 (0.77) $p = 0.37$
ISS > 15	148/1244 (11.9)	140/1133 (12.4) $p = 0.732$	46/213 (21.6) $p = 0.001$	138/853 (16.2) $p = 0.005$
Head injury[a]	82/1251 (6.6)	87/986 (8.8) $p = 0.044$	46/216 (21.3) $p = 0.001$	80/727 (11.0) $p = 0.001$
Liver injury[a]	20/220 (9.1)	36/186 (19.4) $p = 0.003$	12/66 (18.2) $p = 0.04$	31/96 (32.3) $p = 0.001$
Spleen injury[a]	15/259 (5.8)	38/223 (17.0) $p = 0.001$	9/54 (16.7) $p = 0.006$	21/236 (8.9) $p = 0.184$

Potoka, J Trauma 2000

Journal of Pediatric Surgery (2008) 43, 212–221

ELSEVIER

Journal of Pediatric Surgery

www.elsevier.com/locate/jpedsurg

- 3.15% reduction in mortality if treated in a DTC
- Further 4.84% reduction in mortality if treated at pediatric DTC rather than DTC

Do pediatric patients with trauma in Florida have reduced mortality rates when treated in designated trauma centers?

Etienne E. Pracht[a], Joseph J. Tepas III [b,*], Barbara Langland-Orban[a], Lisa Simpson[c], Pam Pieper[d], Lewis M. Flint[c]

- Compared mortality at non-trauma center, designated trauma center and pediatric designated trauma center
- 27,313 patients evaluated

Pracht, J Ped Surg 2008

There may be benefit to treatment at a (pediatric) trauma center

But…

Are kids typically treated at Trauma Centers or Pediatric Trauma Centers?

Who cares for pediatric trauma patients?

	All Subjects	Young (<5yrs)	Severely-injured (ISS>15)
Level I PTC	19.5%	39.6%	51.9%
Level I or II PTC	27.1%	49.1%	60.5%
Level I PTC or Adult TC	42.8%	49.0%	69.7%
Level I or II PT or Adult TC	67.4%	63.1%	76.7%
Non-Trauma Center (TC)	32.7%	30.7%	16.7%

Myers PAS, 2011

Journal of Pediatric Surgery (2006) 41, 92–98

ELSEVIER

Journal of Pediatric Surgery

www.elsevier.com/locate/jpedsurg

Outcomes and delivery of care in pediatric injury

John C. Densmore[a,b,*], Hyun J. Lim[b], Keith T. Oldham[a,b,c], Karen S. Guice[a,b,c]

Table 4 Outcomes by site of care

Table 2 Site of care (NACHRI designation)

	0-10 y, ISS >15 (%)	All patients (%)
Children's hospital	26.8	10.7
Children's unit	38.1	23.5
Adult hospital	35.1	65.8

B. All patients			
Children's hospital	0.9	8.9	20.2
Children's unit	2.4	17.2	32.4
Adult hospital	1.4	9.7	22.2
	$P < .0001$, χ^2	$P < .0001$, χ^2	$P < .0001$, χ^2

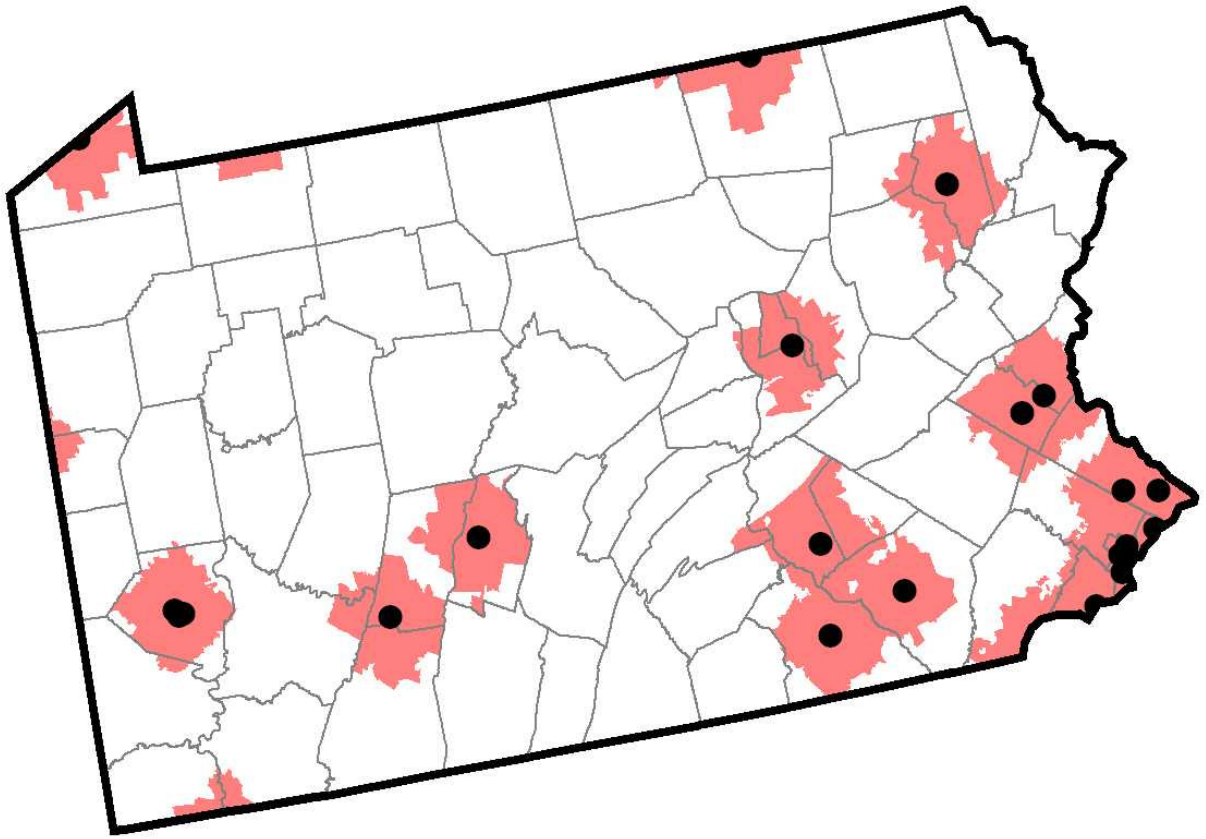
Densmore, J Pediatr Surg 2006

Is access to trauma care equal in the United States?

Trauma Resource Allocation Model for Ambulances and Hospitals (TRAMAH)

- Integer programming optimization model
- Objective to maximize access for severely injured people within ceiling times
- Accounts for both ground and air transport to a trauma center
- Can show existing access and the impact of system changes on access

PA 45 mins By Driving Only With Neighboring States

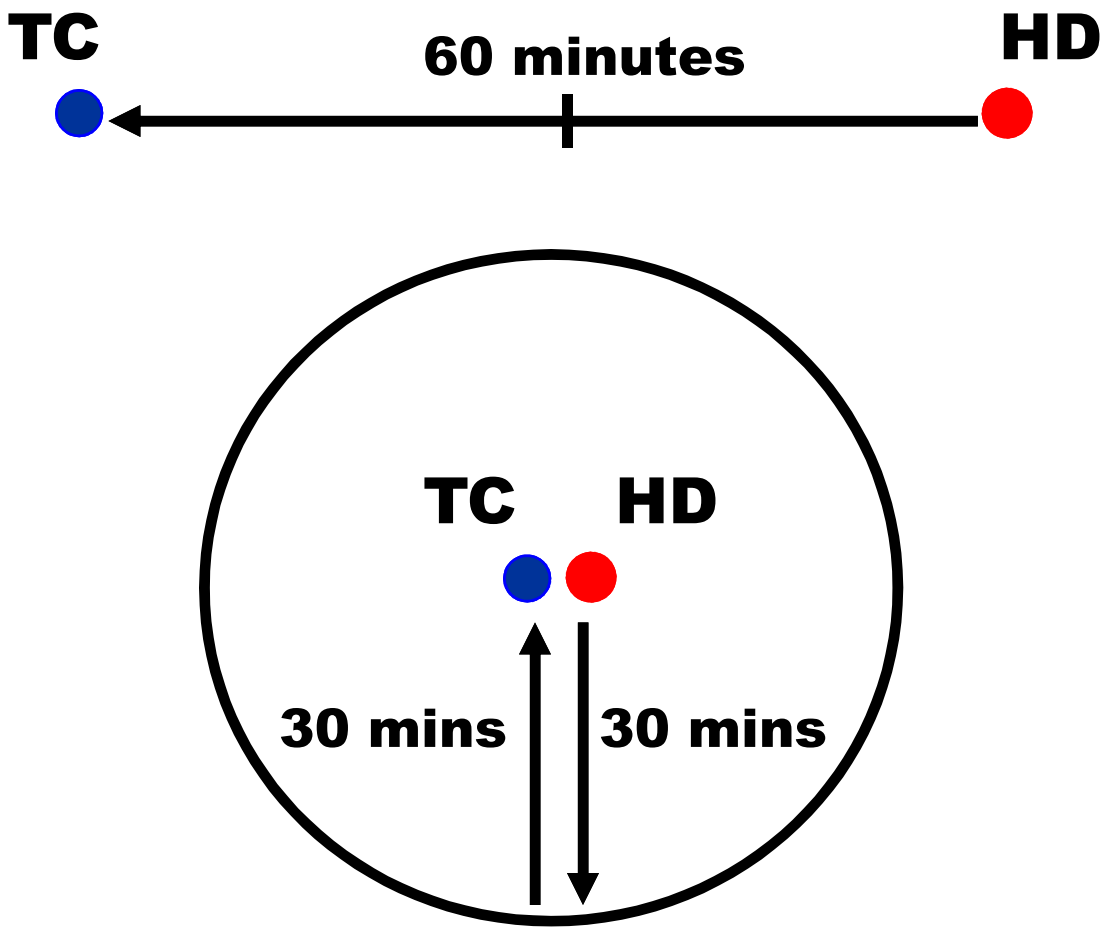


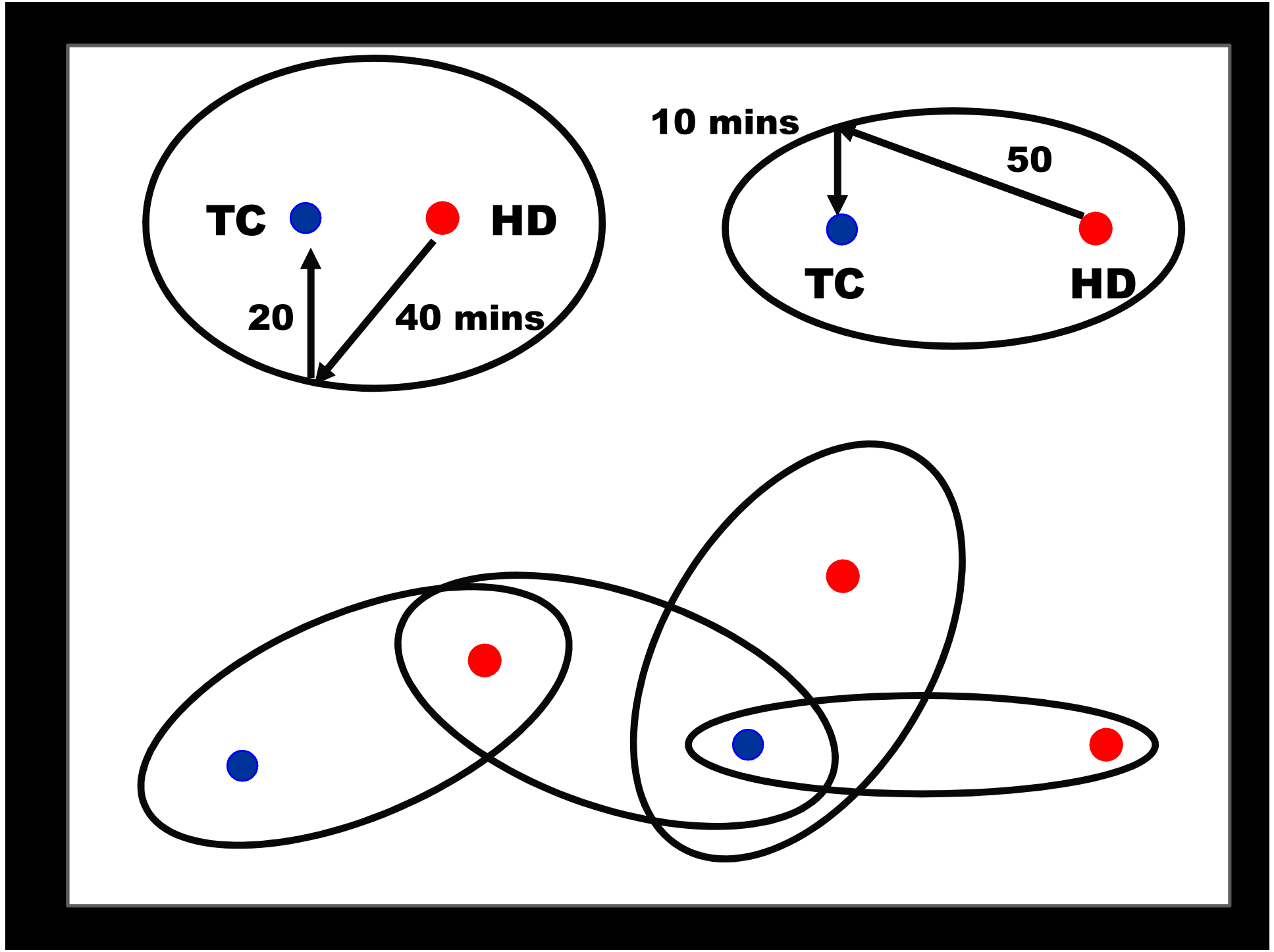
Land Coverage is 17 %
Pop Coverage is 56 %

● Trauma Centers

0 10 20 40 60 80
Miles

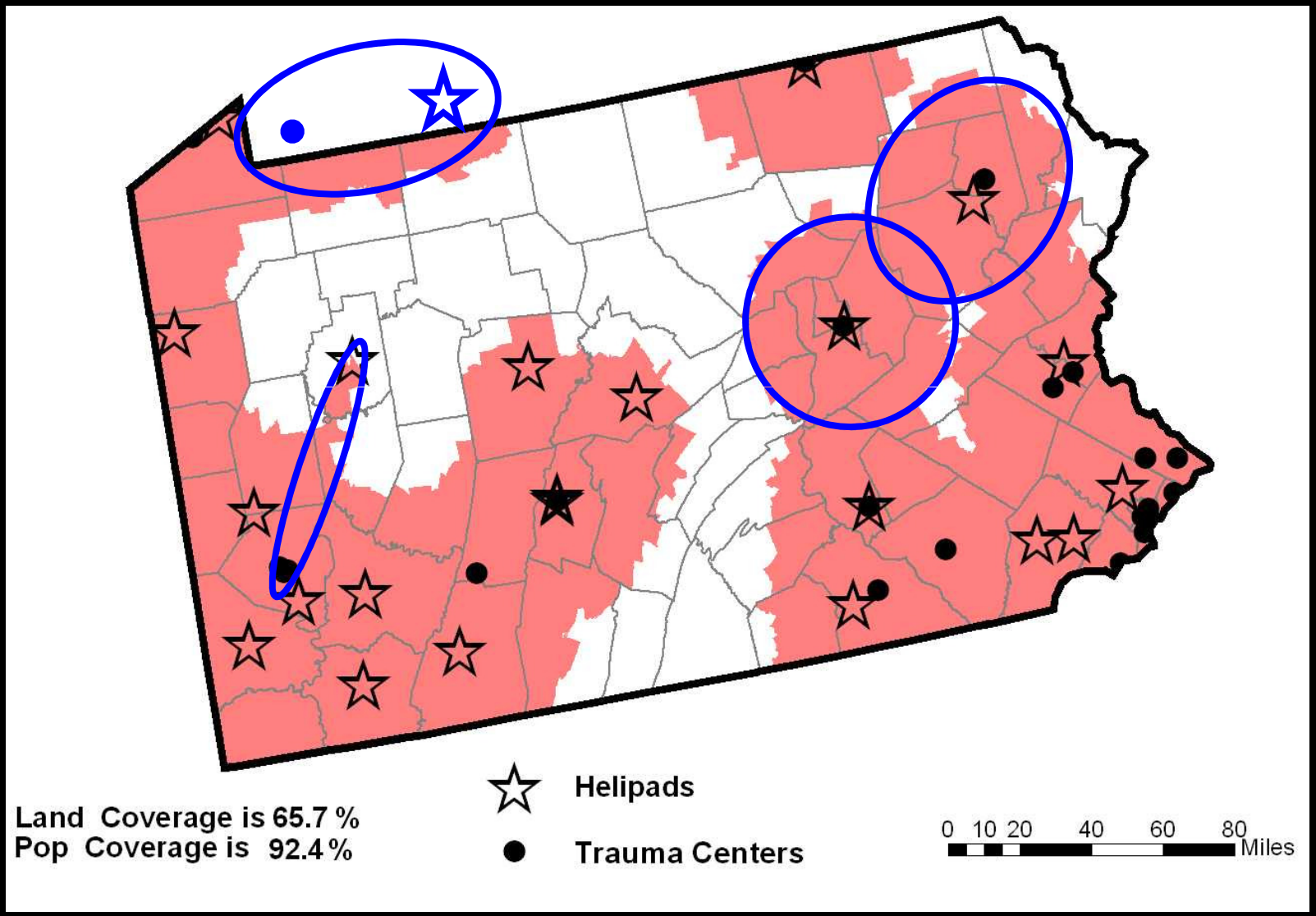
Trauma Center – Helicopter Depot Pairs




TC
HD
20
40 mins
10 mins
50
TC
HD

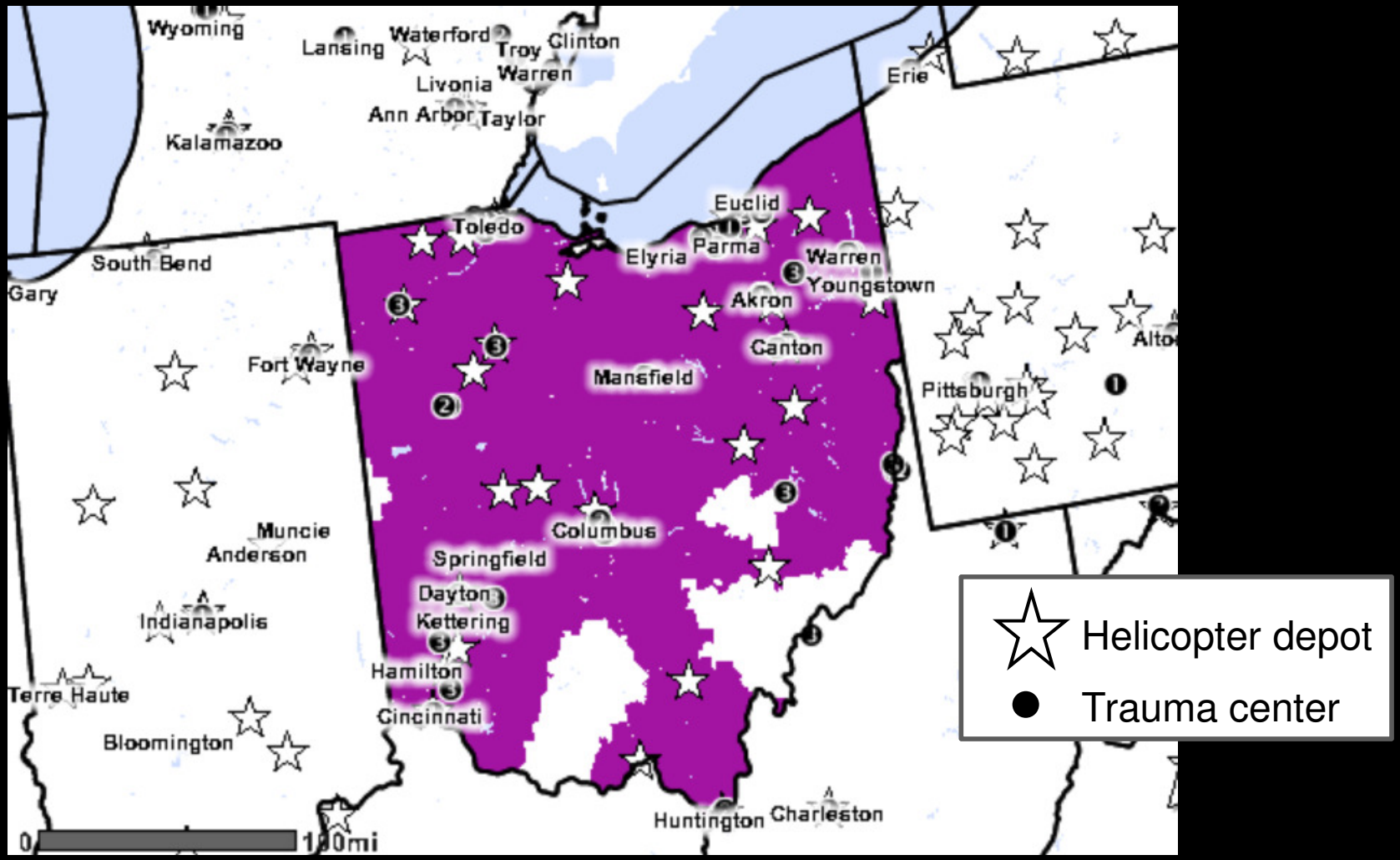
Driving and Flying

(within 45 mins)



Trauma Access

96.4% of population with access to level I/II trauma centers in 60 minutes

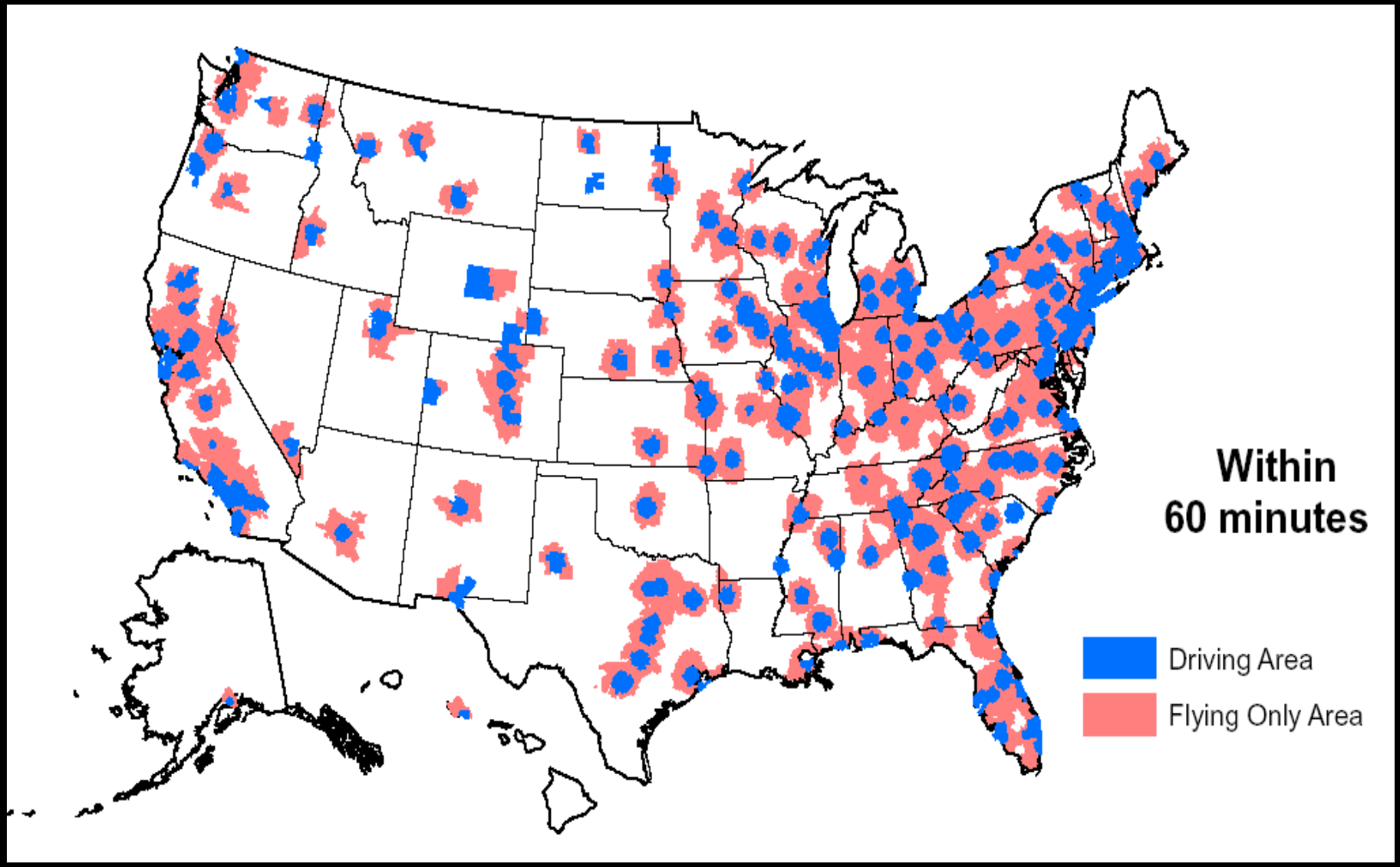


http://tramah.cml.upenn.edu/CML.TraumaCenters.Web/

Branas, JAMA 2005

Transportation types

84.1% of population with access to level I/II trauma centers within 60 minutes

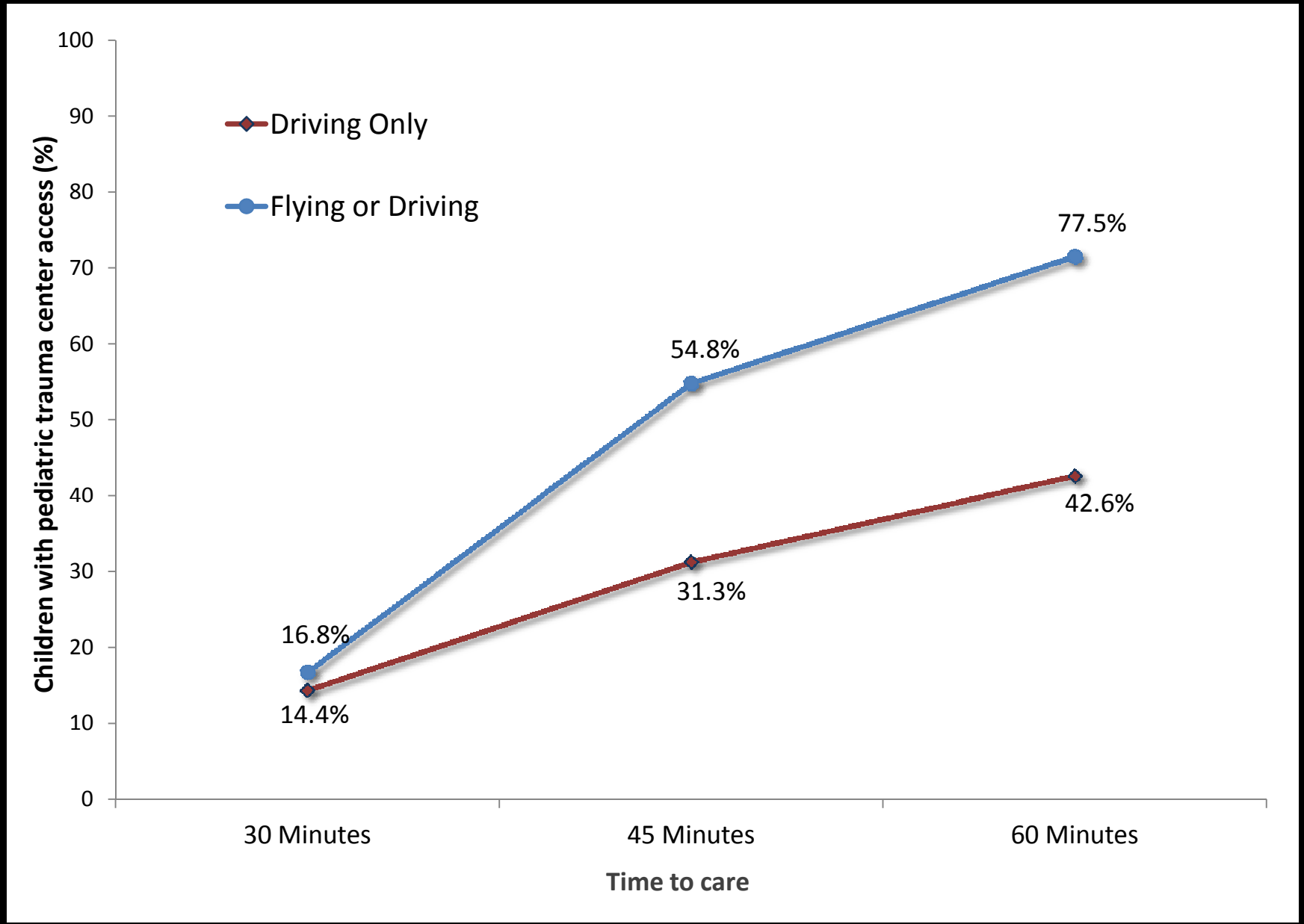


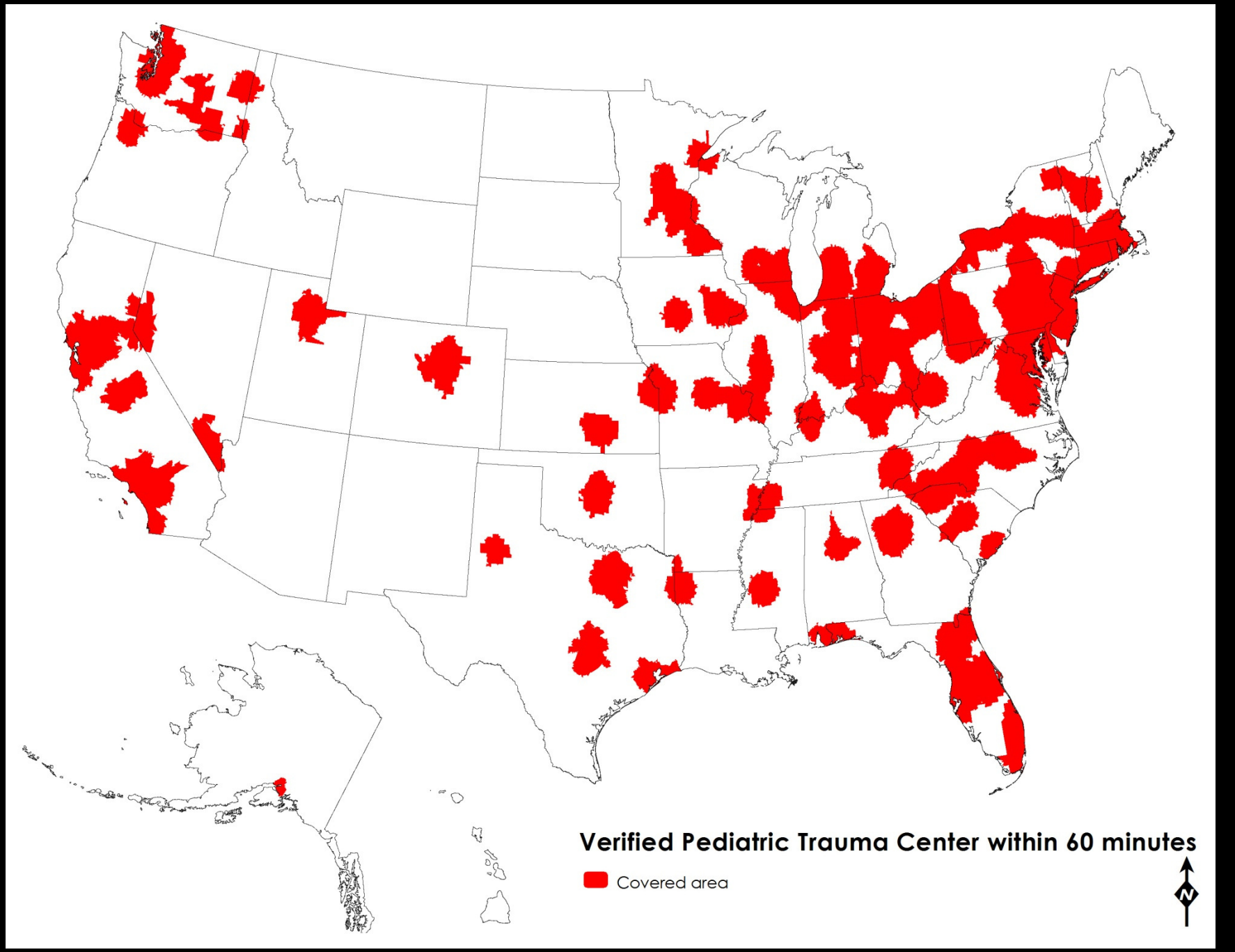
Branas, JAMA 2005

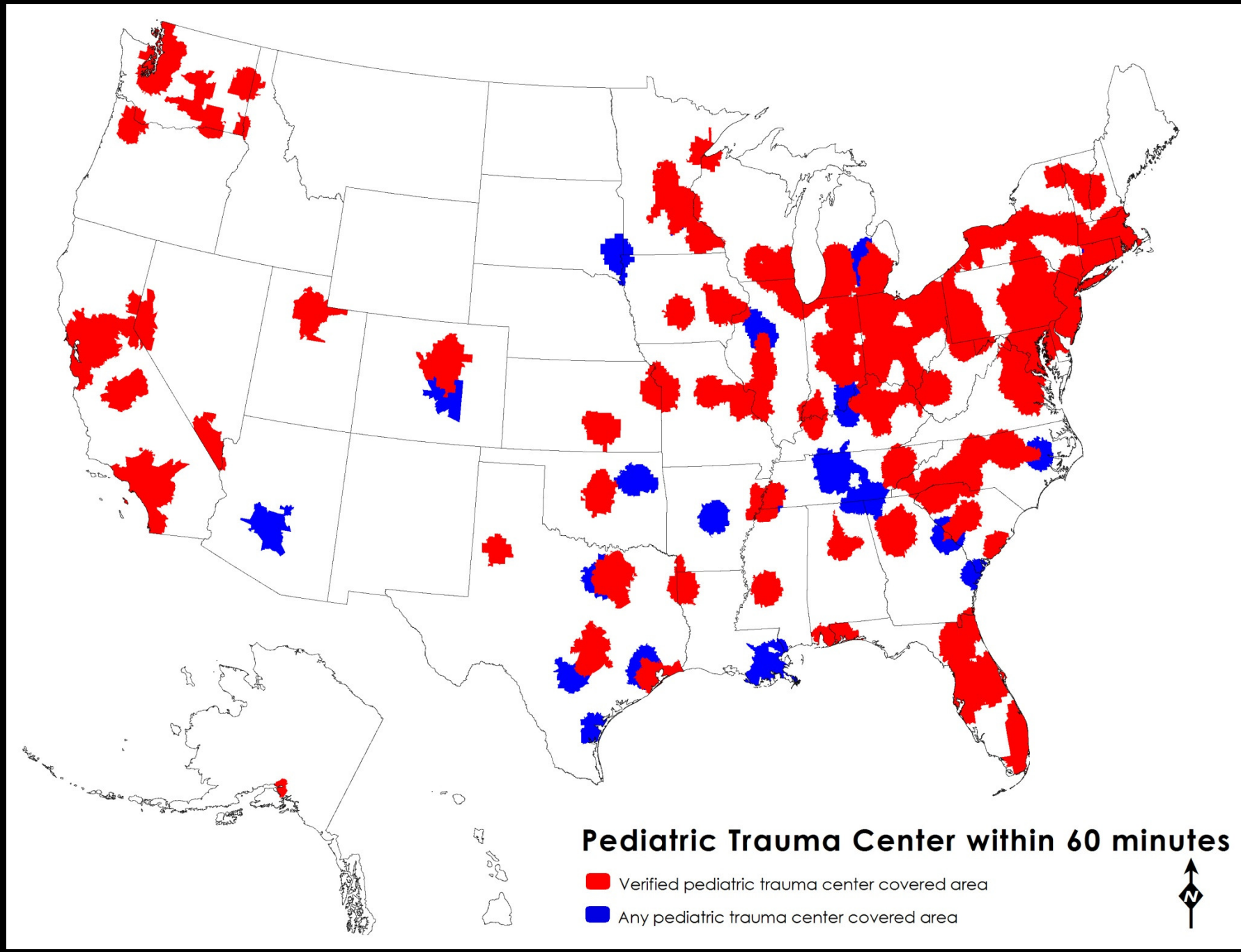
How about access to pediatric trauma resources?

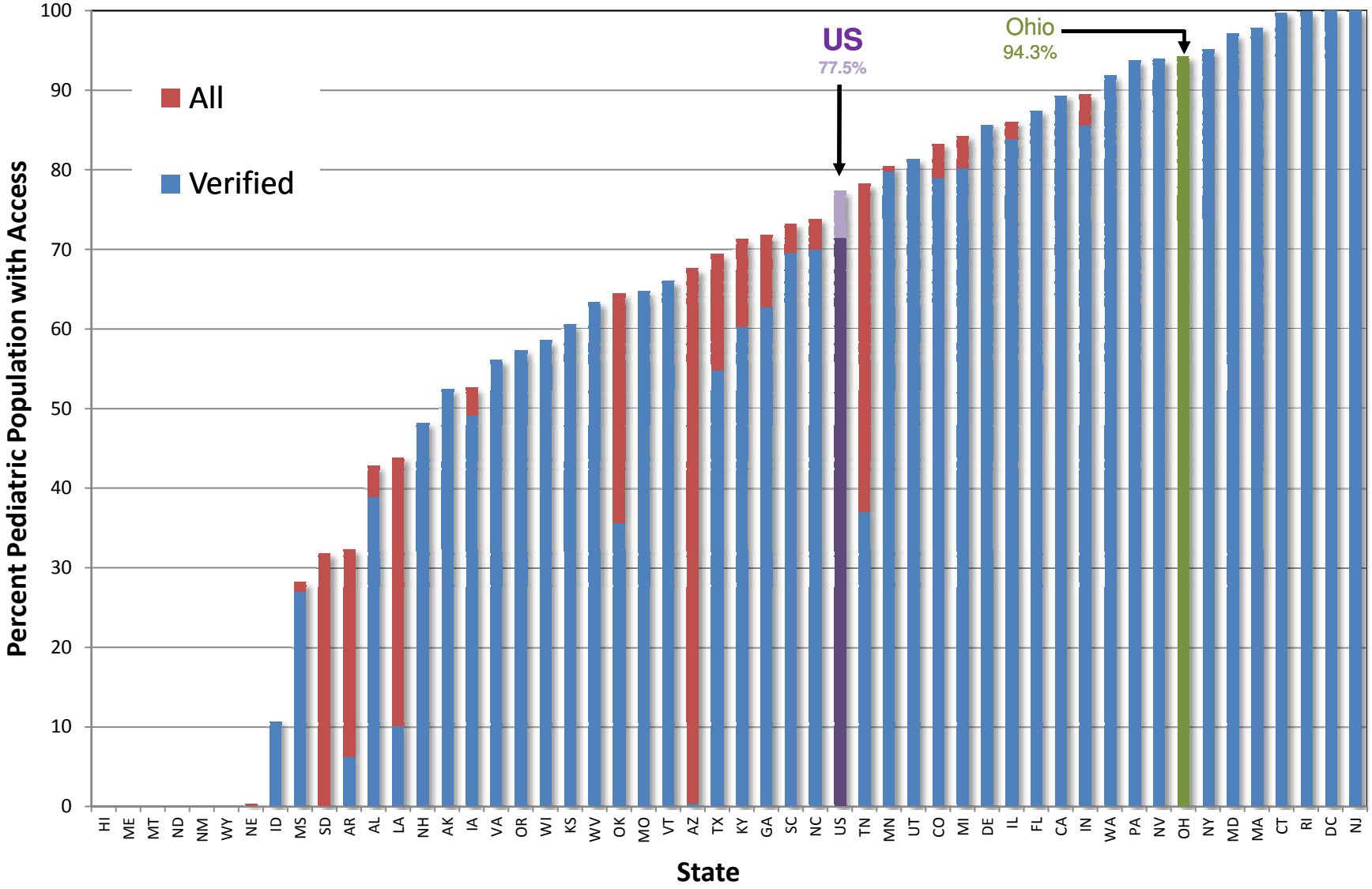
What are pediatric trauma centers and where are they located?

- Methodology similar to adult study
- Needed to create inventory of centers
- Used ACS data, state data, phone calls
- Included “candidate” centers
- Drive time and flight time


Children with pediatric trauma center access (%)
100
90
80
70
60
50
40
30
20
10
0
Driving Only
Flying or Driving
77.5%
54.8%
42.6%
31.3%
16.8%
14.4%
30 Minutes
45 Minutes
60 Minutes
Time to care


Verified Pediatric Trauma Center within 60 minutes
Covered area
N

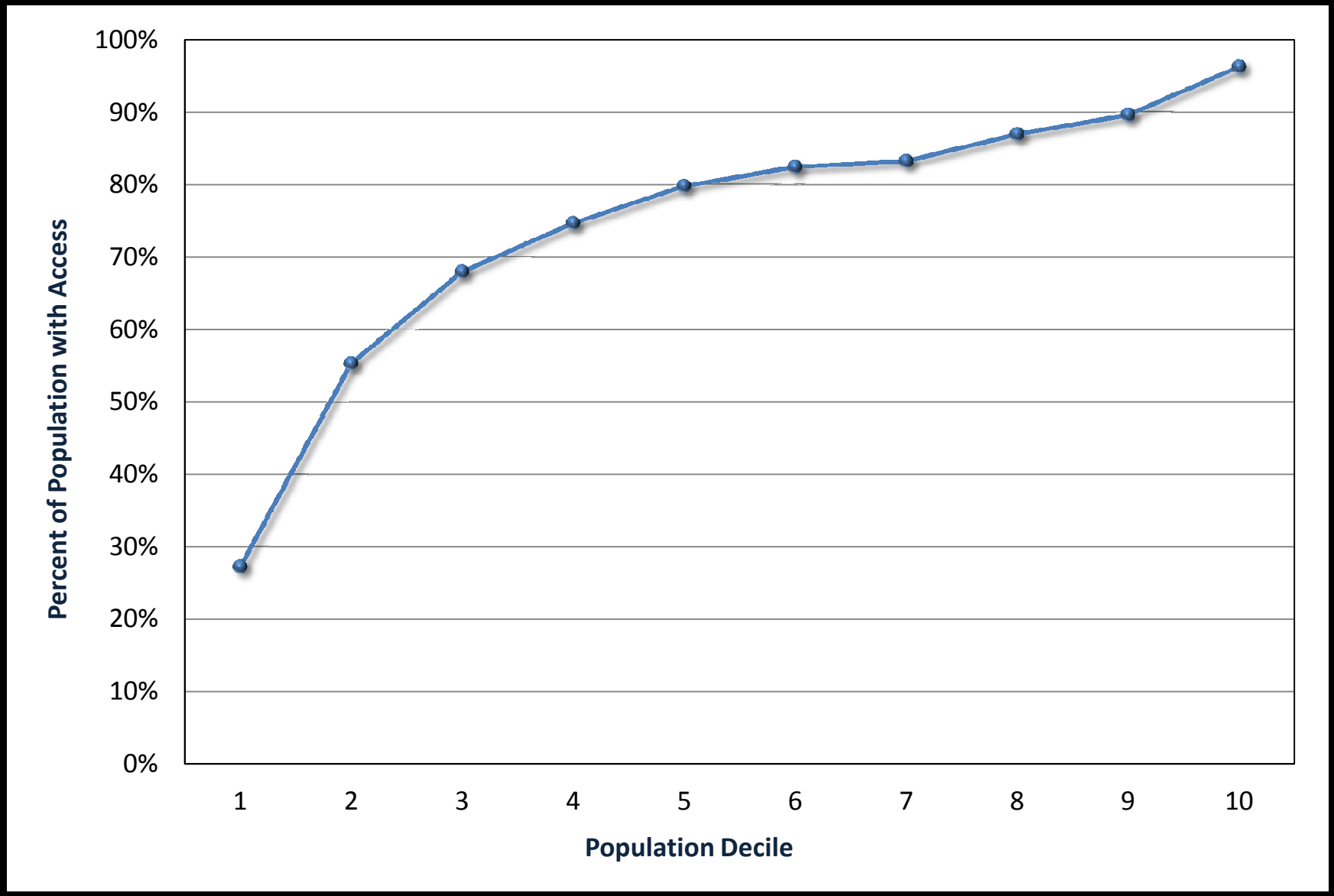

Pediatric Trauma Center within 60 minutes
Verified pediatric trauma center covered area
Any pediatric trauma center covered area
N


US
77.5%
Ohio
94.3%
All
Verified
Percent Pediatric Population with Access
100
90
80
70
60
50
40
30
20
10
0
HI ME MT ND NM WY NE ID MS SD AR AL LA NH AK IA VA OR WI KS WV OK MO VT AZ TX KY GA SC NC US TN MN UT CO MI DE IL FL CA IN WA PA NV OH NY MD MA CT RI DC NJ
State

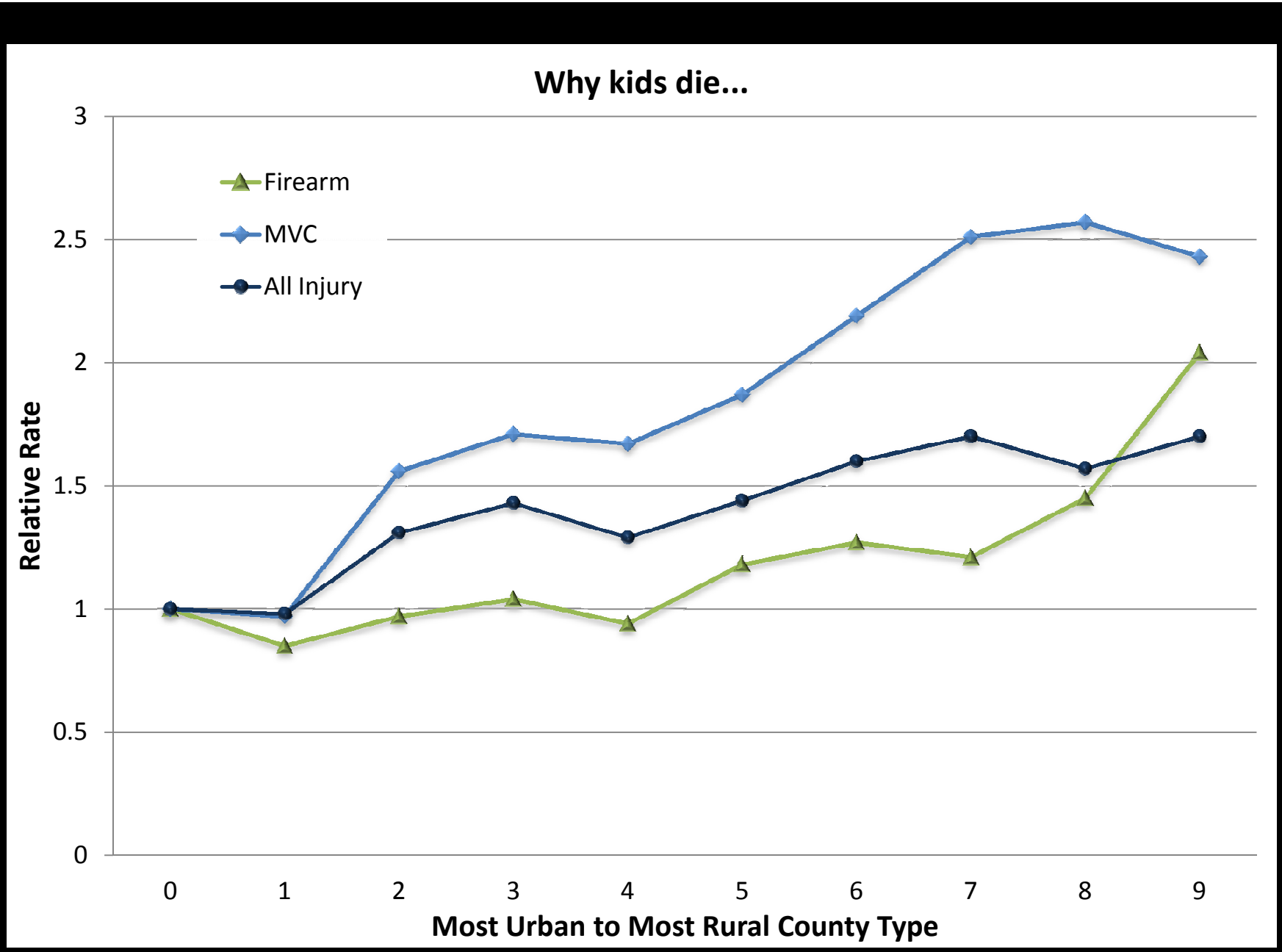
- 170 centers in the US
- 77.5% of pediatric population within 1 hour (flying or driving)
- 14 million children without PTC access within an hour
- Varied by state from 0-100%

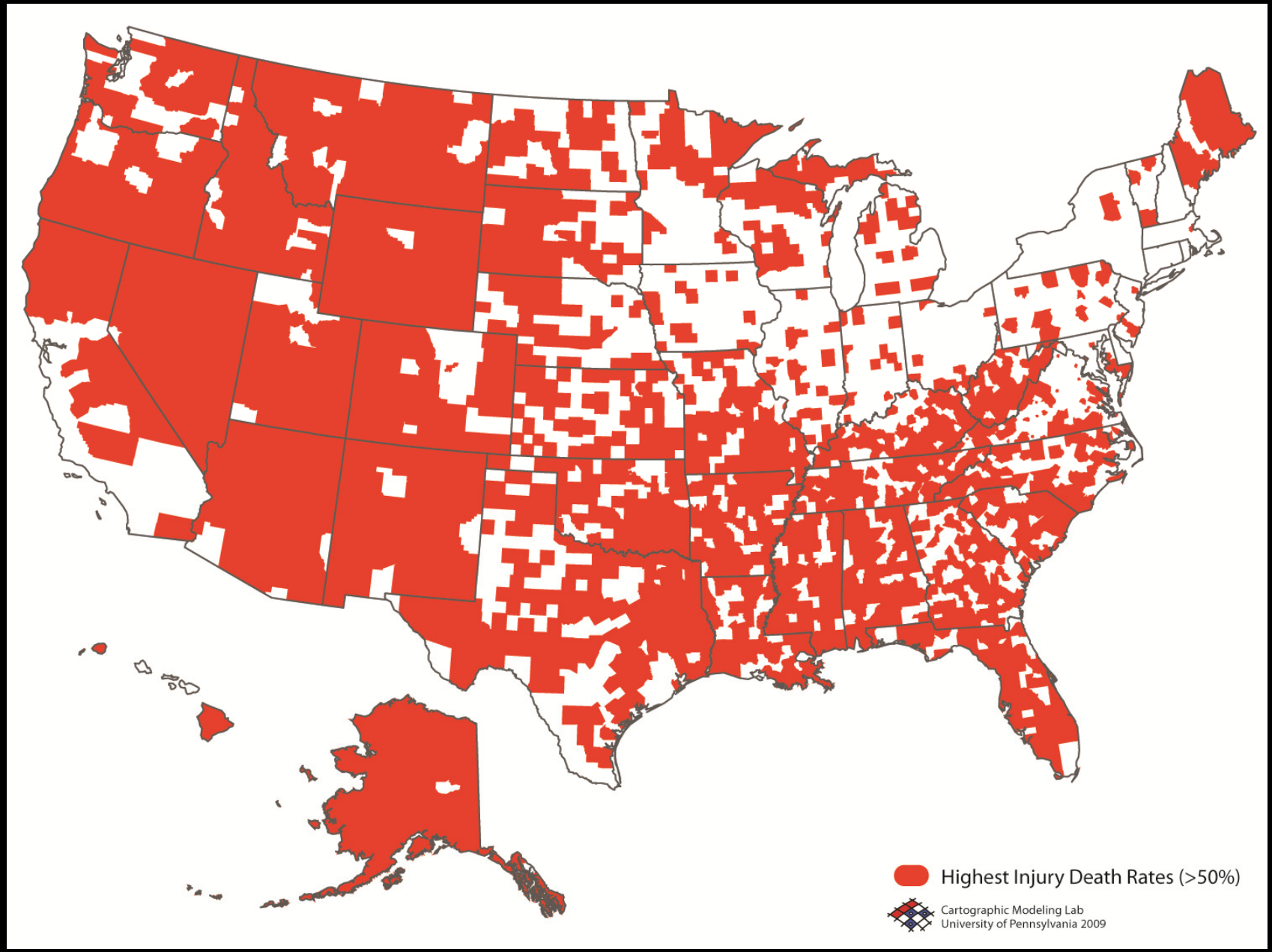
Nance, Arch Ped Adol Med, 2009

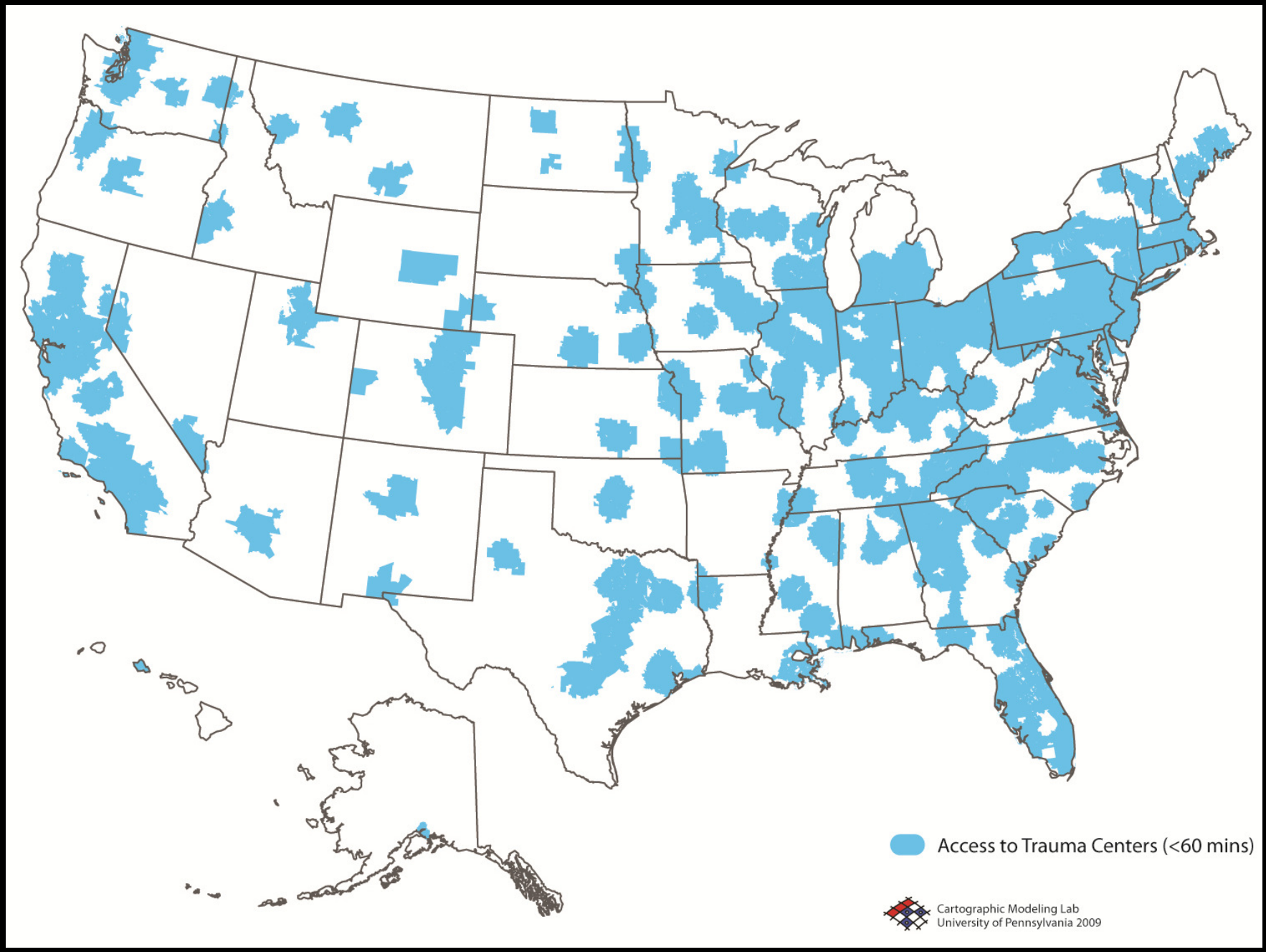
Does access vary by rurality?

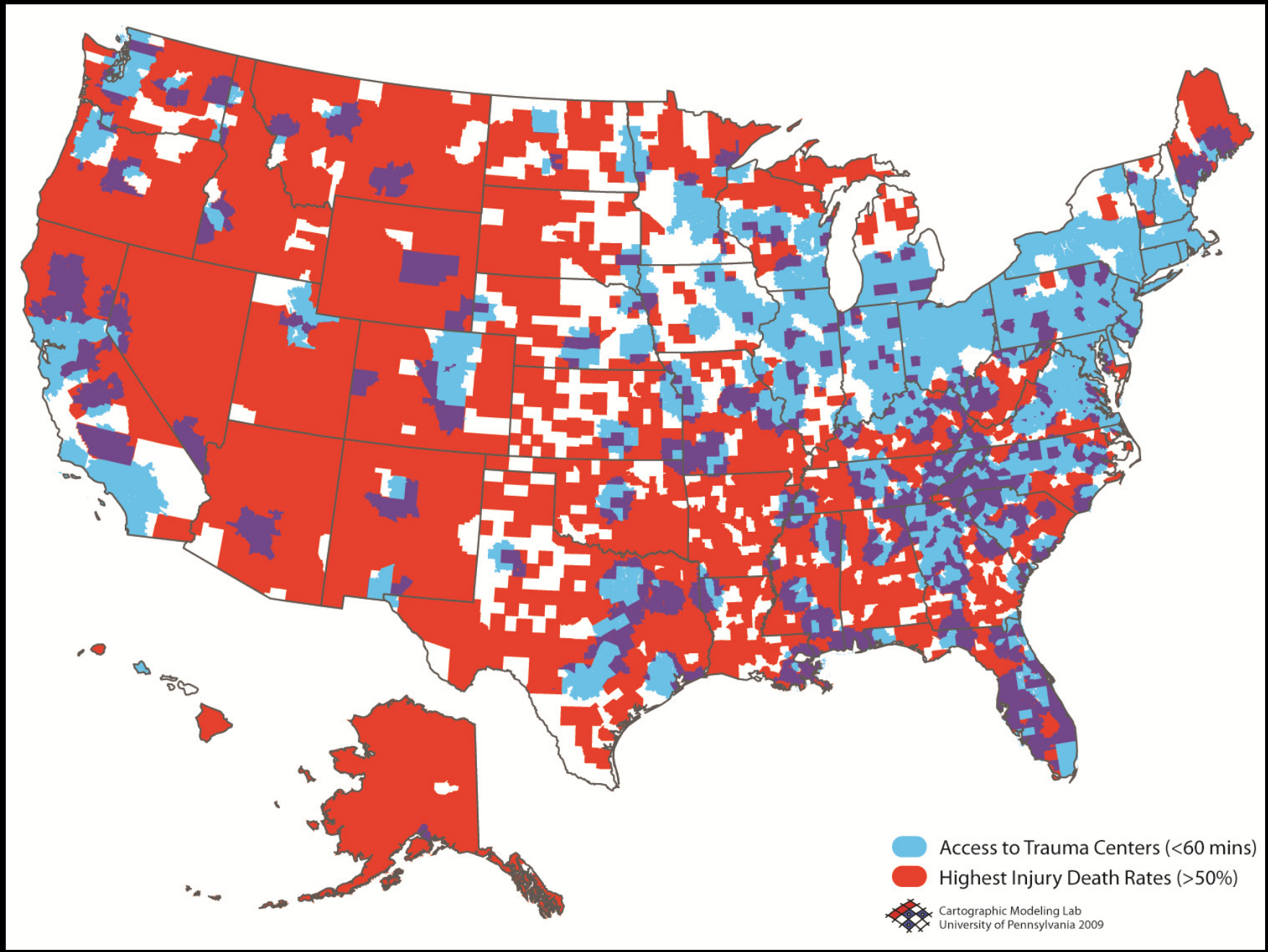

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent of Population with Access
1
2
3
4
5
6
7
8
9
10
Population Decile

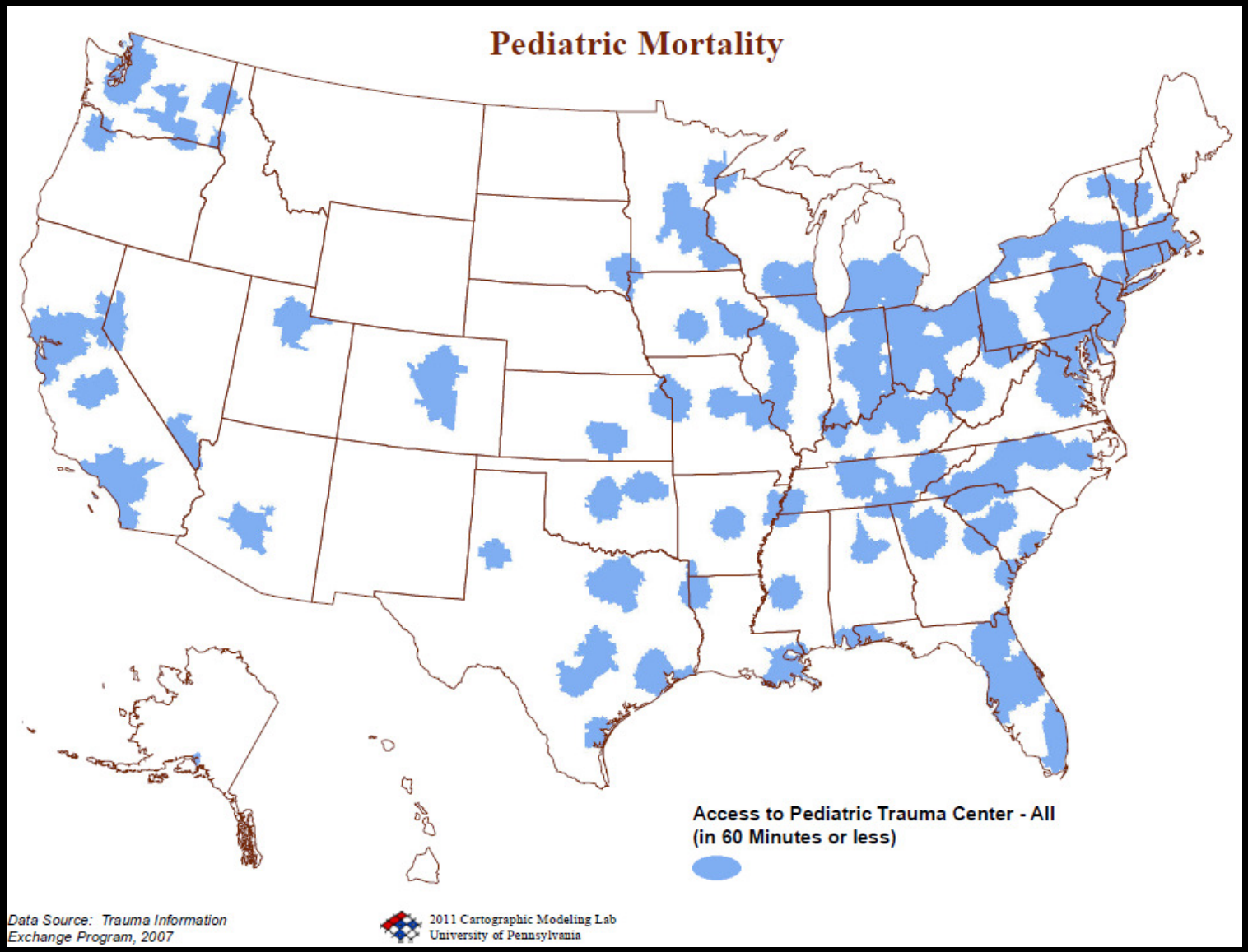
Does rurality impact trauma-related outcome?

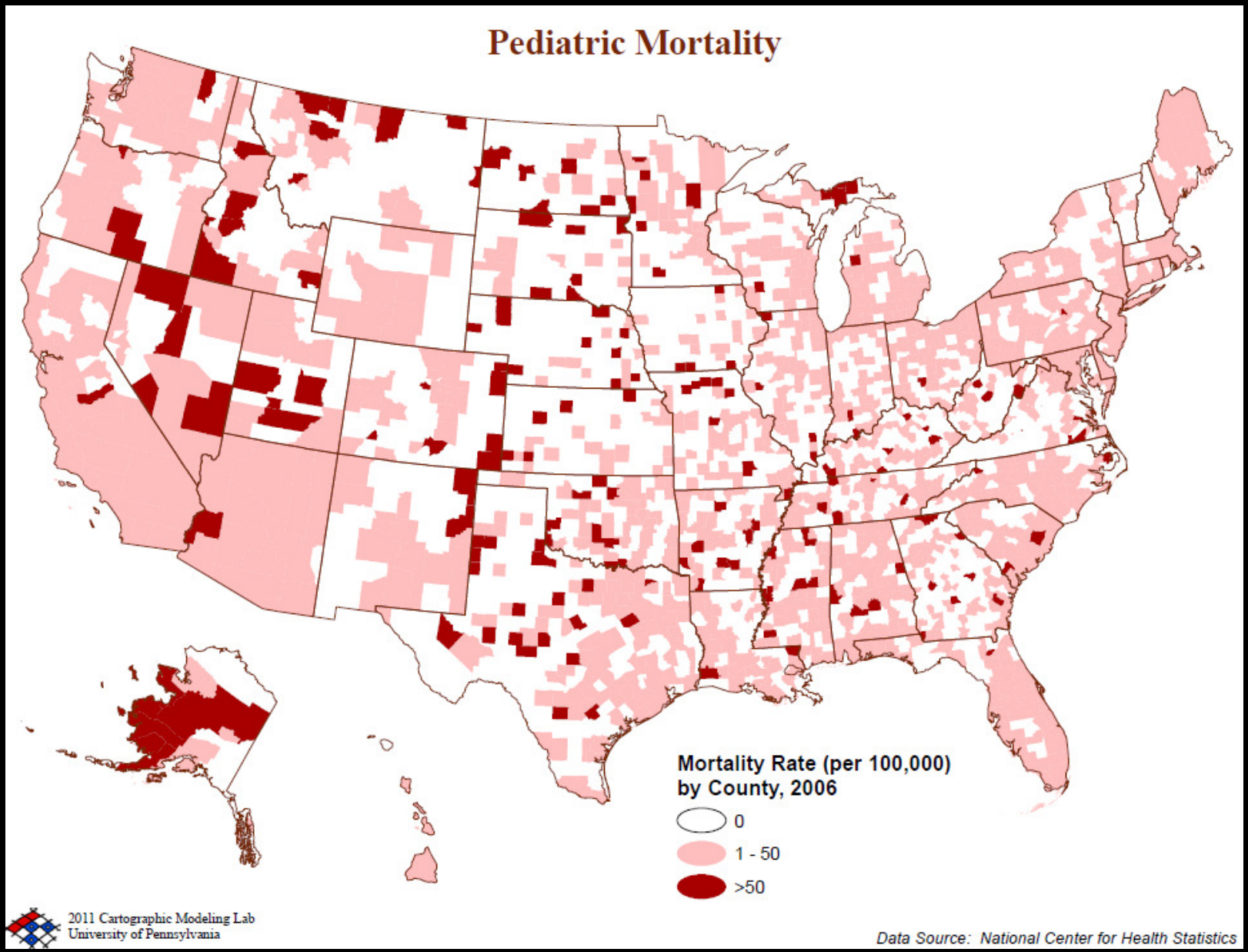

Why kids die...
Firearm
MVC
All Injury
Relative Rate
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
Most Urban to Most Rural County Type


Highest Injury Death Rates (>50%)
Cartographic Modeling Lab
University of Pennsylvania 2009


Access to Trauma Centers (<60 mins)
Cartographic Modeling Lab
University of Pennsylvania 2009


Access to Trauma Centers (<60 mins)
Highest Injury Death Rates (>50%)
Cartographic Modeling Lab
University of Pennsylvania 2009


Pediatric Mortality
Access to Pediatric Trauma Center - All
(in 60 Minutes or less)
Data Source: Trauma Information Exchange Program, 2007
2011 Cartographic Modeling Lab
University of Pennsylvania


Pediatric Mortality
Mortality Rate (per 100,000)
by County, 2006
0
1 - 50
>50
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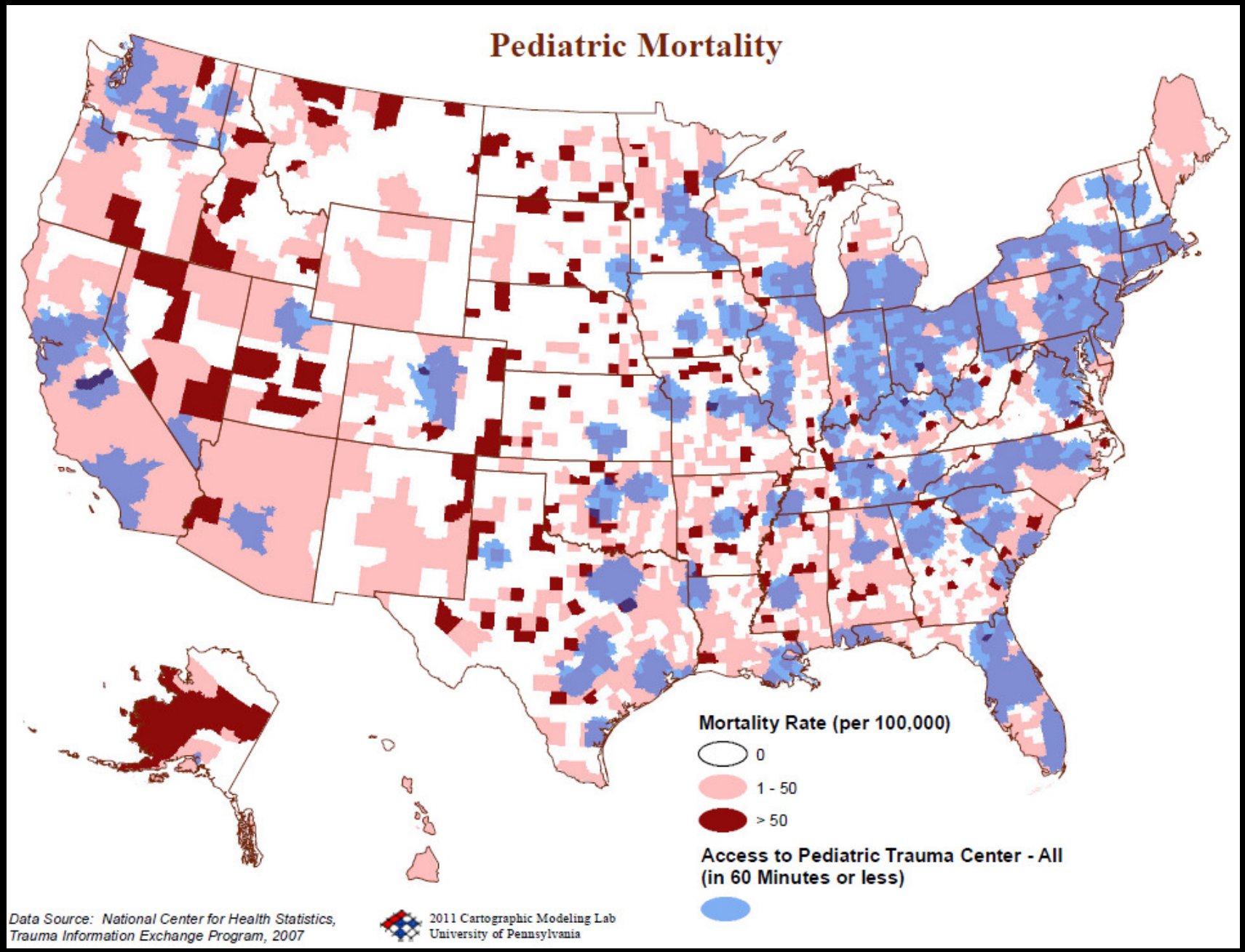
University of Pennsylvania
Data Source: National Center for Health Statistics


Pediatric Mortality
Mortality Rate (per 100,000)
0
1 - 50
> 50
Access to Pediatric Trauma Center - All
(in 60 Minutes or less)
Data Source: National Center for Health Statistics,
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- (Pediatric) Trauma Centers improve care over non-Trauma centers
- Pediatric Trauma Centers may offer improved survival and other benefits over TC and/or non-TC
- Access to TC-based care in the US is not equal in either adult or pediatric populations
- Less access to TC-based care in more rural areas
- Trauma mortality is higher in rural areas

Access likely impacts outcome…

…but direct evidence is lacking