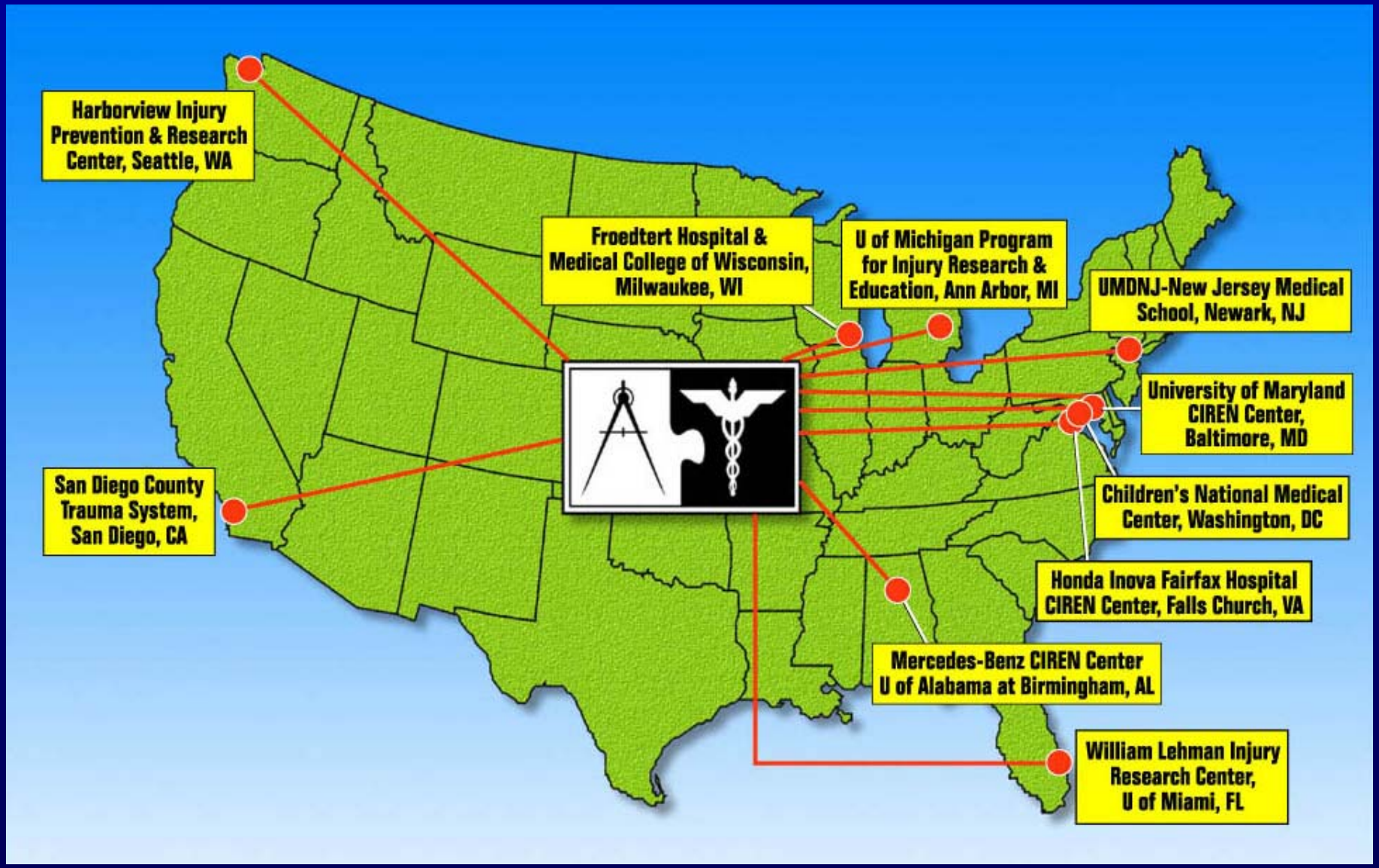
Crash Assessment for Field Triage

"Rules and Exceptions"

Stewart Wang, M.D., Ph.D.
University of Michigan
Trauma Burn Center

Joel MacWilliams
University of Michigan
Transportation Research Institute

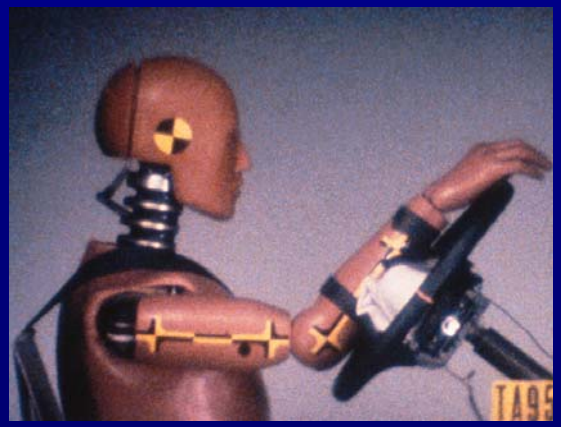
University of Maryland
Baltimore, Maryland
November 4, 20004

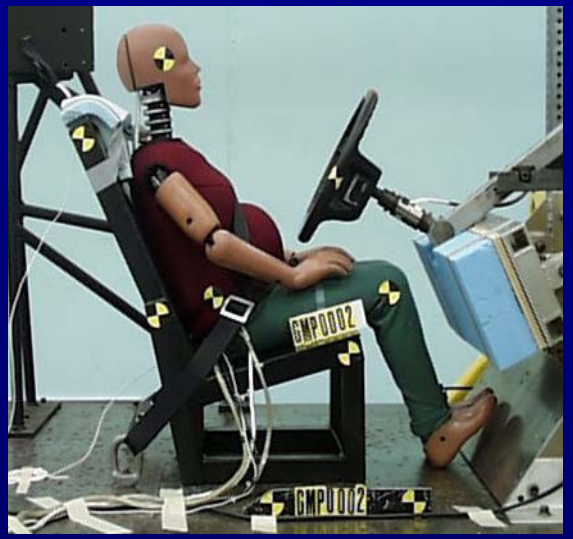

Harborview Injury Prevention & Research Center, Seattle, WA
Froedtert Hospital & Medical College of Wisconsin, Milwaukee, WI
U of Michigan Program for Injury Research & Education, Ann Arbor, MI
UMDNJ-New Jersey Medical School, Newark, NJ
University of Maryland CIREN Center, Baltimore, MD
San Diego County Trauma System, San Diego, CA
Children's National Medical Center, Washington, DC
Honda Inova Fairfax Hospital CIREN Center, Falls Church, VA
Mercedes-Benz CIREN Center U of Alabama at Birmingham, AL
William Lehman Injury Research Center, U of Miami, FL

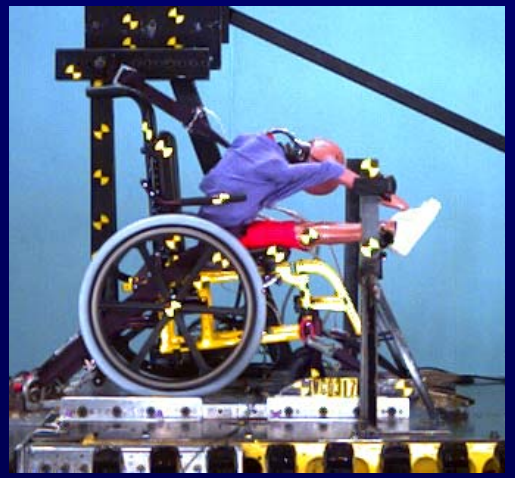
UMTRI

UMPIRE

University of Michigan Transportation Research Institute







UMTRI

UMPIRE

Motor Vehicle Crashes

1,000,000 deaths per year worldwide

No. 4 global health problem by the year 2020 – W.H.O.

Crashes in the USA

~40,000 killed
(115/day, 1/13 minutes)

~3,000,000 injured

~$230 Billion

Riding in a car continues to be the most dangerous thing you do on a daily basis

ABC's of Vehicle Assessment

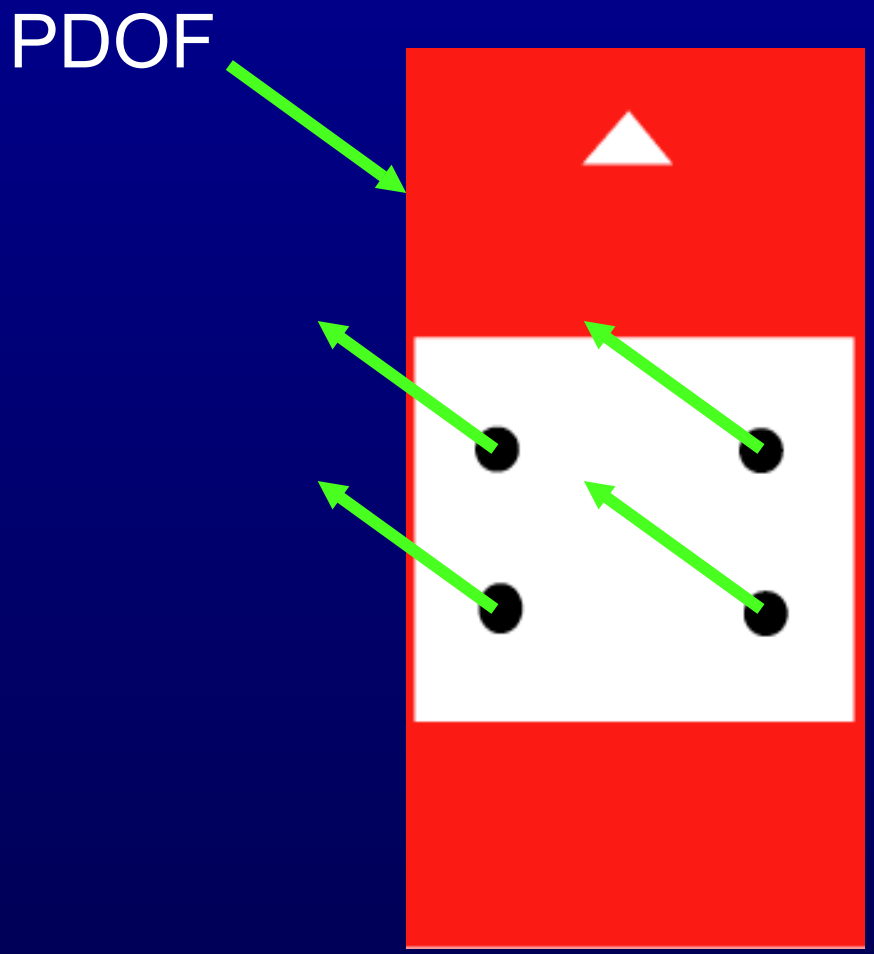
ABC's of Vehicle Assessment

- **A** is for "Angle" or more precisely Principle Direction of Force (PDOF)

ABC's of Vehicle Assessment

- **A** is for "Angle" or more precisely Principle Direction of Force (PDOF)
- Why is PDOF important?

PDOF and Occupant Response



Occupant Response is <u>equal</u> and <u>opposite</u> to the PDOF

ABC's of Vehicle Assessment

Newton's Third Law of Motion…..

For every action (force) in nature, there is an equal and opposite reaction

ABC's of Vehicle Assessment

….which tells us the patient's

- likely path of travel,
- side of body likely injured,
- the parts of the vehicle that are likely injury sources, and
- the direction from which unsecured cargo and/or unrestrained occupants may have struck the patient from the "backside" of the PDOF

ABC's of Vehicle Assessment

- Remember
  - The other occupants in the vehicle (injured or not) often interact during the crash sequence and can be the source of a patients injury

ABC's of Vehicle Assessment

- Remember
  - The other occupants in the vehicle (injured or not) often interact during the crash sequence and can be the source of a patients injury
  - Unsecured cargo is also a potential injury source - e.g. text books, portable DVD players, golf clubs, softball equipment, water heaters, laptops, bowling balls, etc.

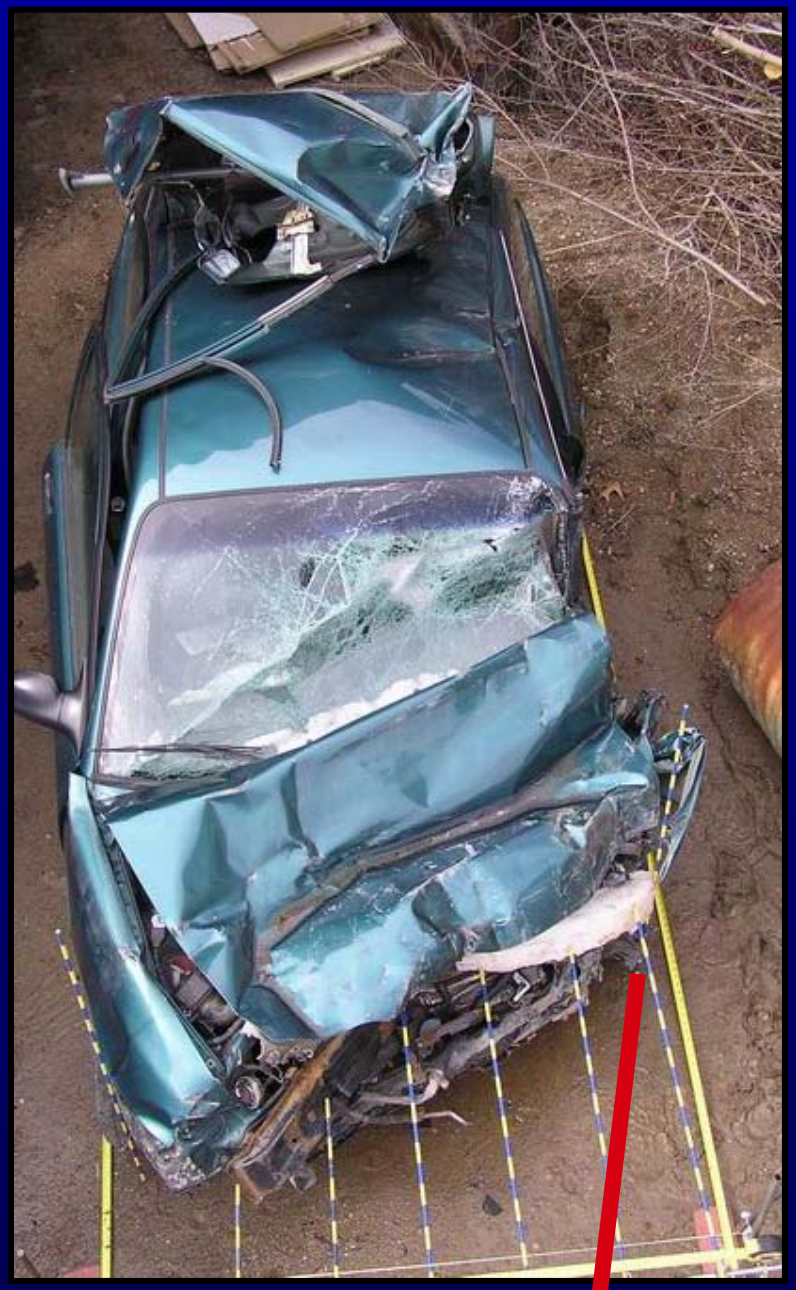
ABC's of Vehicle Assessment

- How to quickly assess the PDOF of a given vehicle

Quick Assessment of PDOF

- The “Superman” technique

  - if you could grab a piece of the vehicle with one finger and pull in one direction, what direction would you pull in order to restore the car to its original shape



UMTRI

UMPIRE

UMTRI

UMPIRE

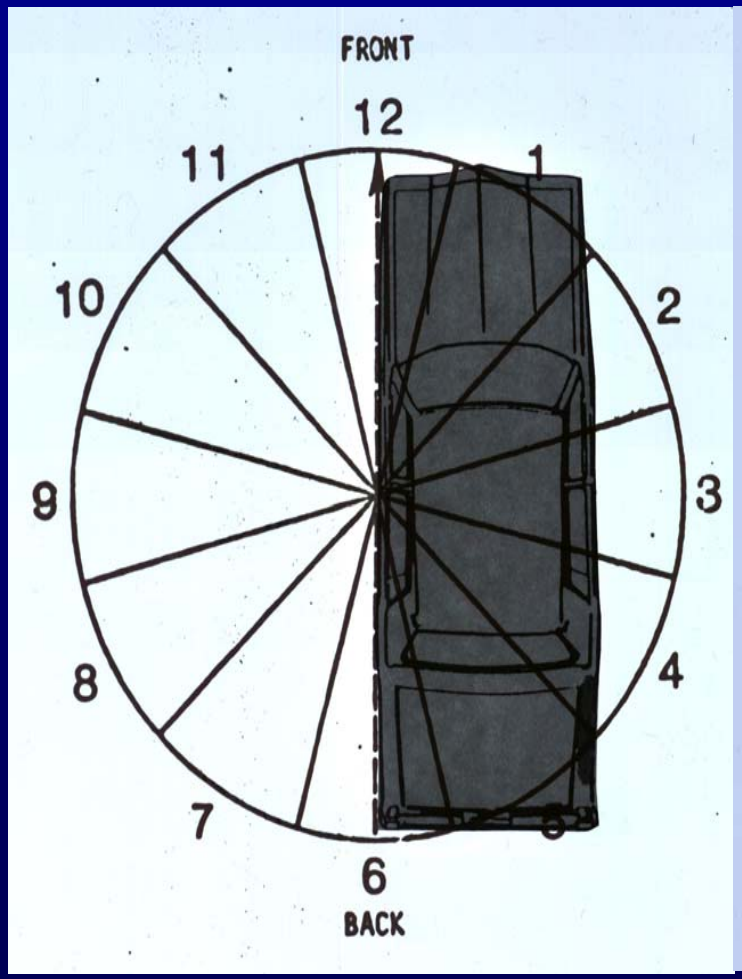
UMTRI

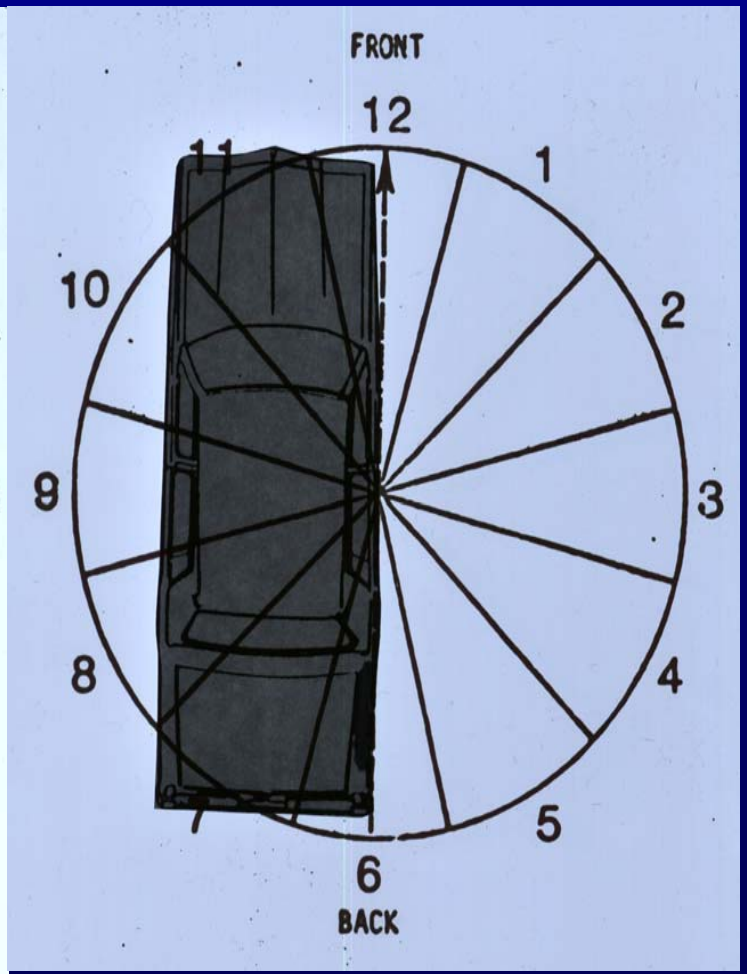
UMPIRE

ABC's of Vehicle Assessment

- Precision is not required
- An "o'clock" interpretation is sufficient

O'CLOCK / PDOF





ABC's of Vehicle Assessment

- **B** is for "Belts & Bags"

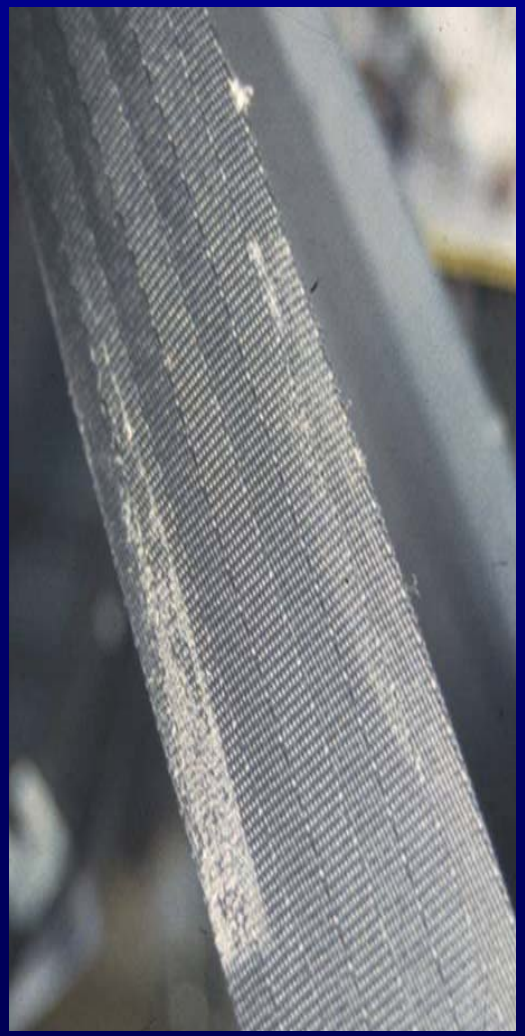
Field Assessment of Belt Use

- Seatbelt D-rings
- Seatbelt “Continuous Loops”
- Seatbelt webbing
- Seatbelt load limiters
- Seatbelt post-crash modes
  - Locked in extended or retracted position
  - Webbing cut with tongue in buckle
  - Webbing cut without tongue in buckle
- Steering-wheel rim deformation

D-rings

Continuous Loops

Webbing Marks



Load Limiters

Post-Crash Belt Mode

Belt “locked” in extended mode post-crash - will not retract

Post-Crash Belt Mode

Belt “locked” in retracted mode post-crash - will not extend

Post-Crash Webbing Cut

Post-Crash Webbing Cut

Post-Crash Webbing Cut

ABC's of Vehicle Assessment

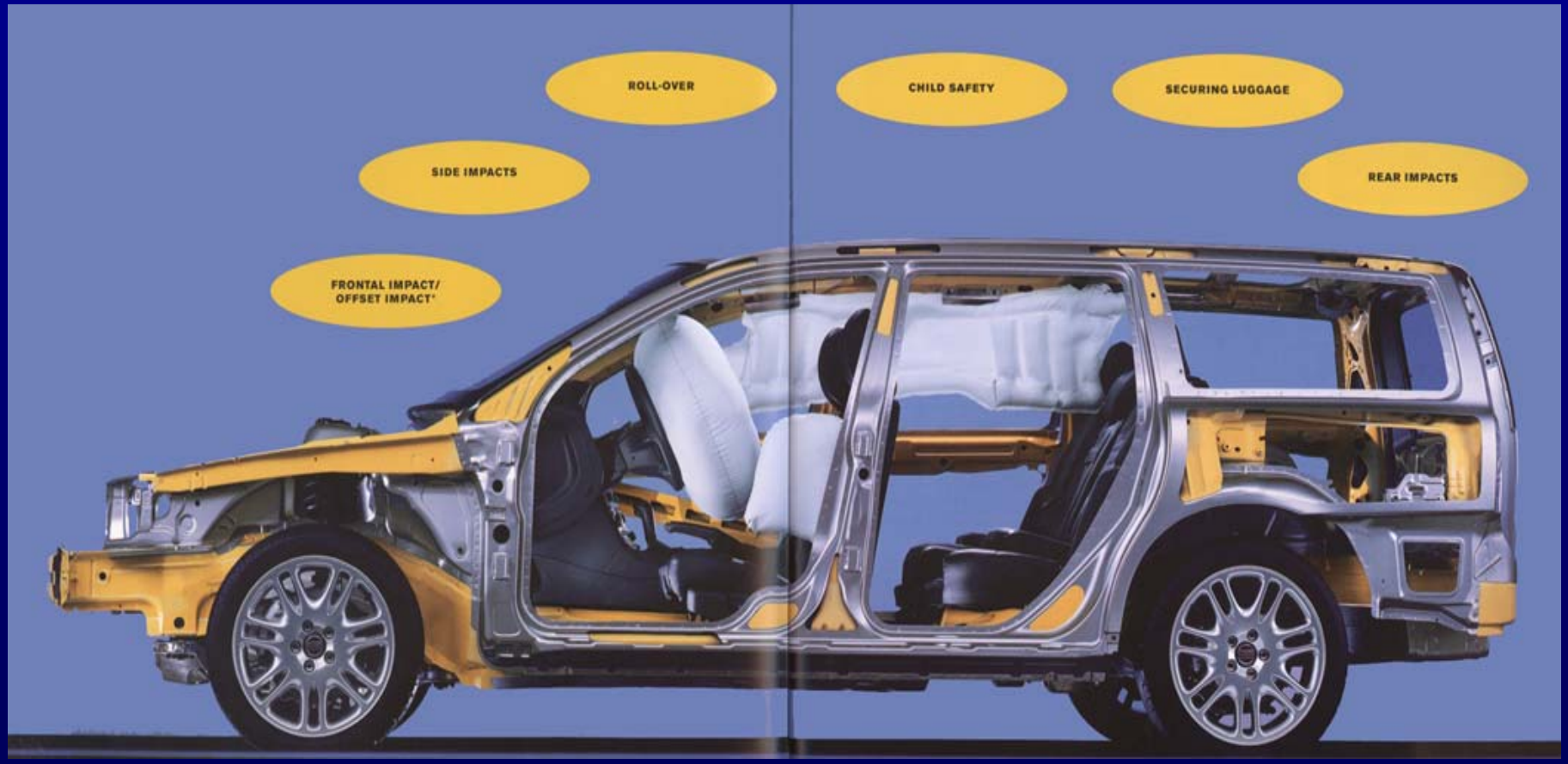
- Loading evidence of belt systems is not always so grossly obvious

Lower SW rim deformation is “usually” indicative of an unbelted driver

Upper SW rim deformation is “usually” indicative of a belted driver

Upper and lower SW rim deformation tends to occur in higher severity crashes and can be either be a belted or unbelted driver

ABC's of Vehicle Assessment



ABC's of Vehicle Assessment

ABC's of Vehicle Assessment

ABC's of Vehicle Assessment

ABC's of Vehicle Assessment

ABC's of Vehicle Assessment

- Rule - belted occupants may still contact interior components in higher severity crashes

ABC's of Vehicle Assessment

- Rule - belted occupants may still contact interior components in higher severity crashes
- Rule - in general, belt restrained occupants fare well in most crashes

ABC's of Vehicle Assessment

- Rule - belted occupants may still contact interior components in higher severity crashes
- Rule - in general, belt restrained occupants fare well in most crashes
- **Exceptions - improperly belted, inappropriately belted, very young and the very old**

ABC's of Vehicle Assessment

- Rule - airbag restrained occupants generally enjoy good protection from head to abdomen

ABC's of Vehicle Assessment

- Rule - airbag restrained occupants generally enjoy good protection from head to abdomen
- **Exception - unbelted occupants can often miss or skip off the airbag (angled PDOFs)**

ABC's of Vehicle Assessment

- Rule - airbag restrained occupants generally enjoy good protection from head to abdomen
- Exception - unbelted occupants can often miss or skip off the airbag (angled PDOFs)
- **Exception - occupants who are out-of-position (OOP) can sustain "inflation injuries" - eg flail chest, A-O separation, forearm fractures, brain injuries (angular acceleration)**

ABC's of Vehicle Assessment

- **C** is for "Crash Severity"

ABC's of Vehicle Assessment

Minor - Frontal

- Minimal hood deformation
- No wheelbase reduction
- Appears "driveable"

ABC's of Vehicle Assessment

Minor - Side

No wheelbase reduction

4 inches or less of door intrusion

Vehicle generally driveable

ABC's of Vehicle Assessment

Moderate - Frontal

- Moderate hood deformation
- Typically not driveable
- Minimal or no wheelbase reduction
- Minimal intrusion; typically limited to floor/toepan

ABC's of Vehicle Assessment

Moderate - Side

- 4-6 inches of door intrusion
- Minimal or no wheelbase reduction
- Doors may be jammed but no entrapment (physically pinned by vehicle component)

ABC's of Vehicle Assessment

Severe - Frontal

Significant hood deformation

Obvious wheelbase reduction

Remote buckling of roof due to A-pillar movement

Dash, floor, & steering column intrusion common

ABC's of Vehicle Assessment

Severe - Side

More than 6 inches of door intrusion

Roof buckling

Obvious wheelbase reduction

Vehicle may bow (banana shape)

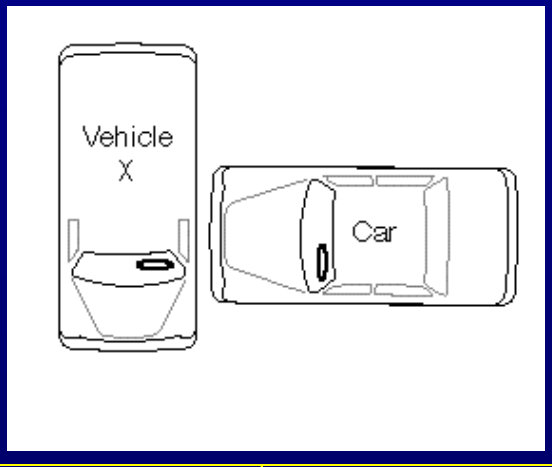
Seat cushion & seat backrest deformation common

Occupant entrapment (physically pinned) more common

Vehicle Incompatibility/Aggressivity

Fatality Ratios From FARS

Car Front to Vehicle-X Left Side

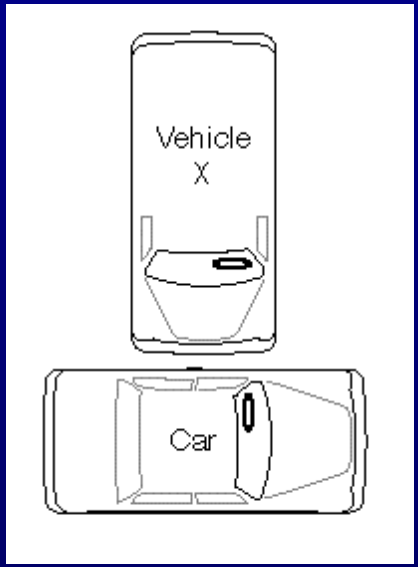


Vehicle X	Fatality Ratio (Veh. XCar)
Car	5.6
S U V	1.4
Van	1.1
Pickup Truck	1.1

Vehicle Incompatibility/Aggressivity

Fatality Ratios from FARS

Vehicle-X Front to Passenger Car Left Side



Vehicle X	Fatality Ratio (Car/Veh. X)
S U V	30
Van	13
Pickup Truck	25

ABC's of Vehicle Assessment

- Rule - injury probability increases as crash severity increases

ABC's of Vehicle Assessment

- Rule - injury probability increases as crash severity increases
- Rule - near-side impacts have higher probability of injury than other crash modes (front, rear)

ABC's of Vehicle Assessment

- Rule - injury probability increases as crash severity increases
- Rule - near-side impacts have higher probability of injury than other crash modes (front, rear)
- **Exceptions - OOP, ejections, cargo, collision partner (mass or geometric incompatibility)**

ABC's of Vehicle Assessment

- **A** is for "Angle" or more precisely Principle Direction of Force (PDOF)
- **B** is for "Belts & Bags"
- **C** is for "Crash Severity"

ABCs of Occupant Assessment

- **A**ge
  - Rule: The extremes of age are more vulnerable to injury (and have decreased physiologic reserve)
  - Exception: Children 3 – 8 fare poorly if not in belt-positioning booster seats.
- **B**ody Habitus
  - Rule: Size does matter – fat is protective.
  - Exception: Side impacts and LEX injuries
- **C**omplaints
  - Rule: Respiratory, neurologic, body trunk
  - Exception: Unable to complain

CASE #2

3 Child Occupants: Ages 3,6 & 7

3

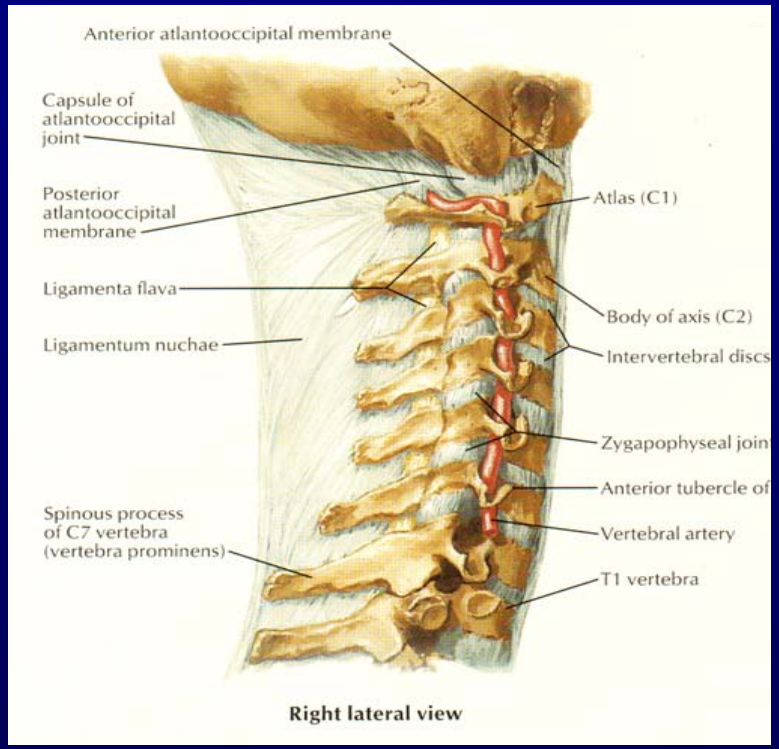
6

7

Outcome

7 year-old right front passenger

- **Bruises**
- **Atlanto-occipital dissociation**



6 year old right rear passenger
Shoulder belt behind back
Lap belt slack

Outcome

6 year-old right rear passenger

- Skull fracture and brain injuries
- Lumbar (L2,3,4) spine fractures
- Multiple intestinal injuries
- Atlanto-occipital dissociation (more severe)

3 year old right front passenger
Shoulder belt behind back

Outcome

3 year-old left rear passenger

- Multiple intestinal injuries
- Pelvic fractures
- Atlanto-occipital dissociation (most severe)

CASE II

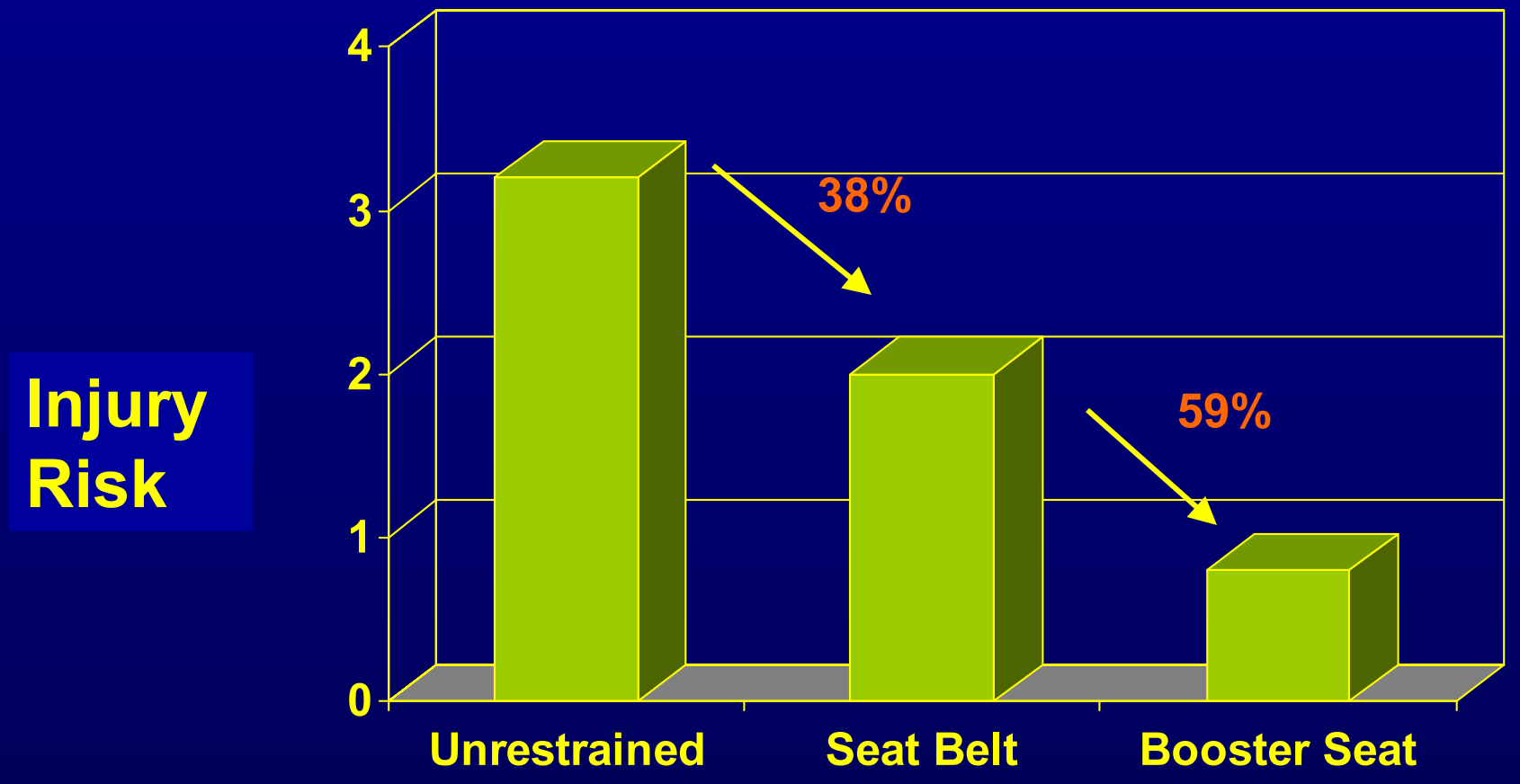
1. Adult Driver
   - No significant injuries

2. 7 year-old right front passenger
   - Atlanto-occipital dissociation

3. 6 year-old right rear passenger
   - Atlanto-occipital dissociation (more severe)
   - Other injuries deleted

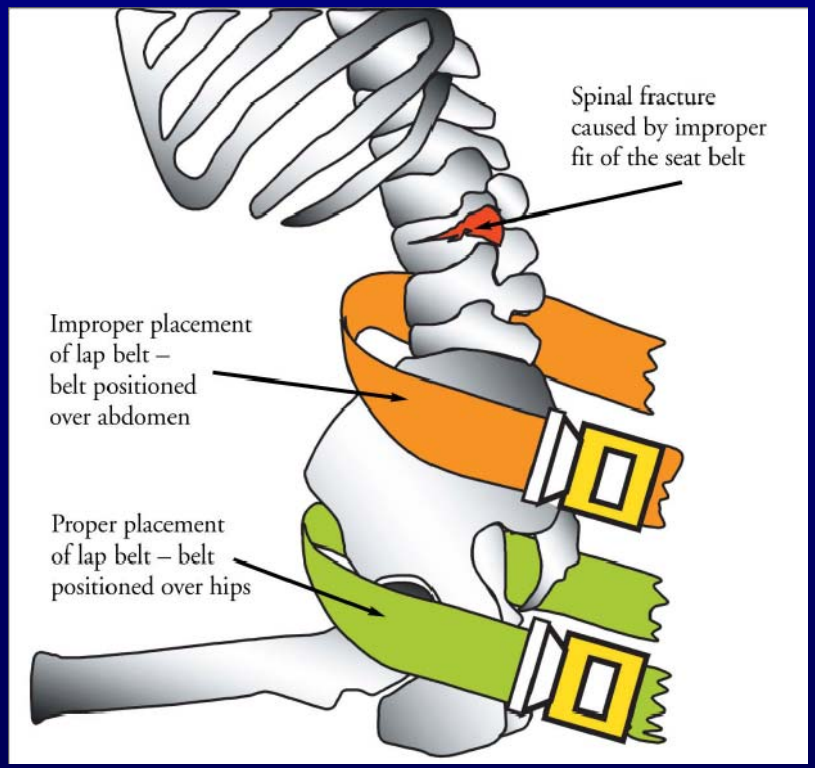
4. 3 year-old left rear passenger
   - Atlanto-occipital dissociation (most severe)
   - Other injuries deleted

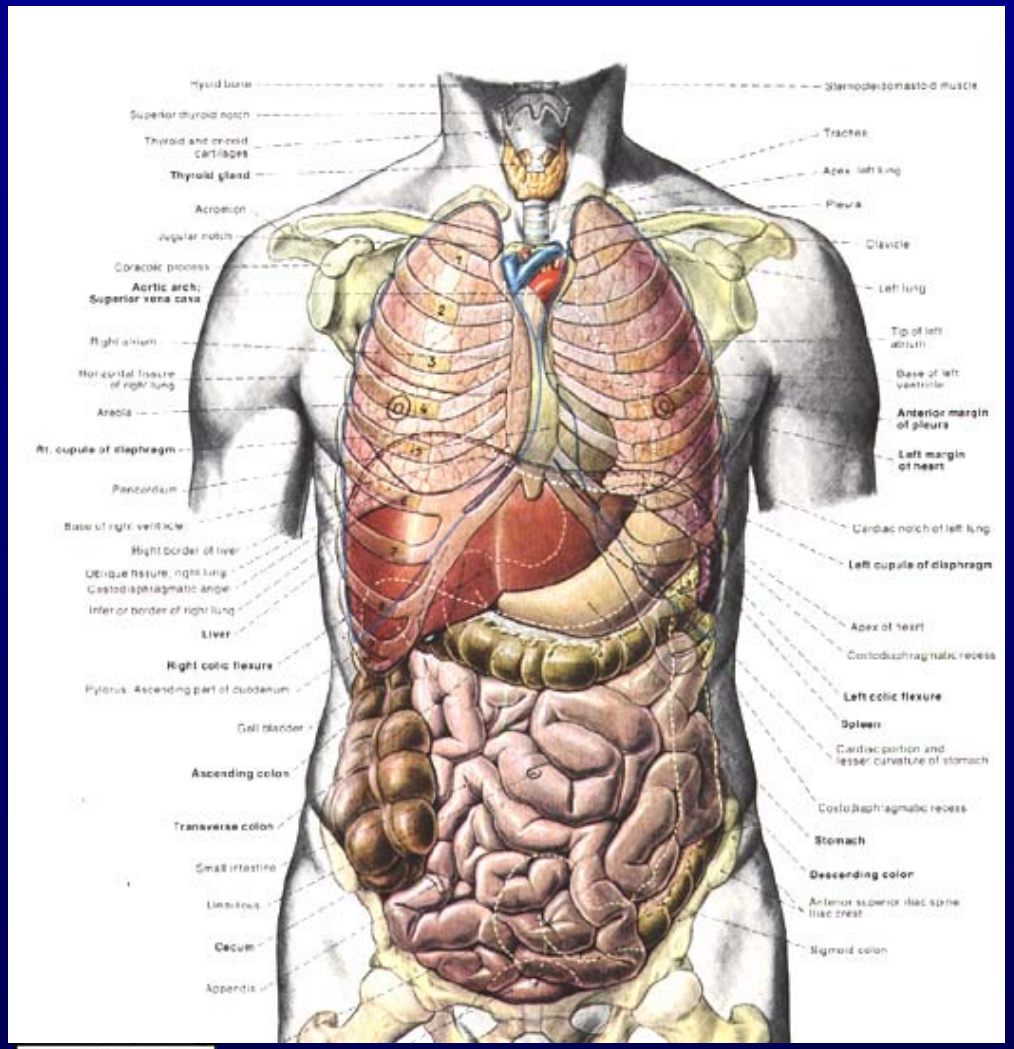
Risk of Injury to Children in Crashes



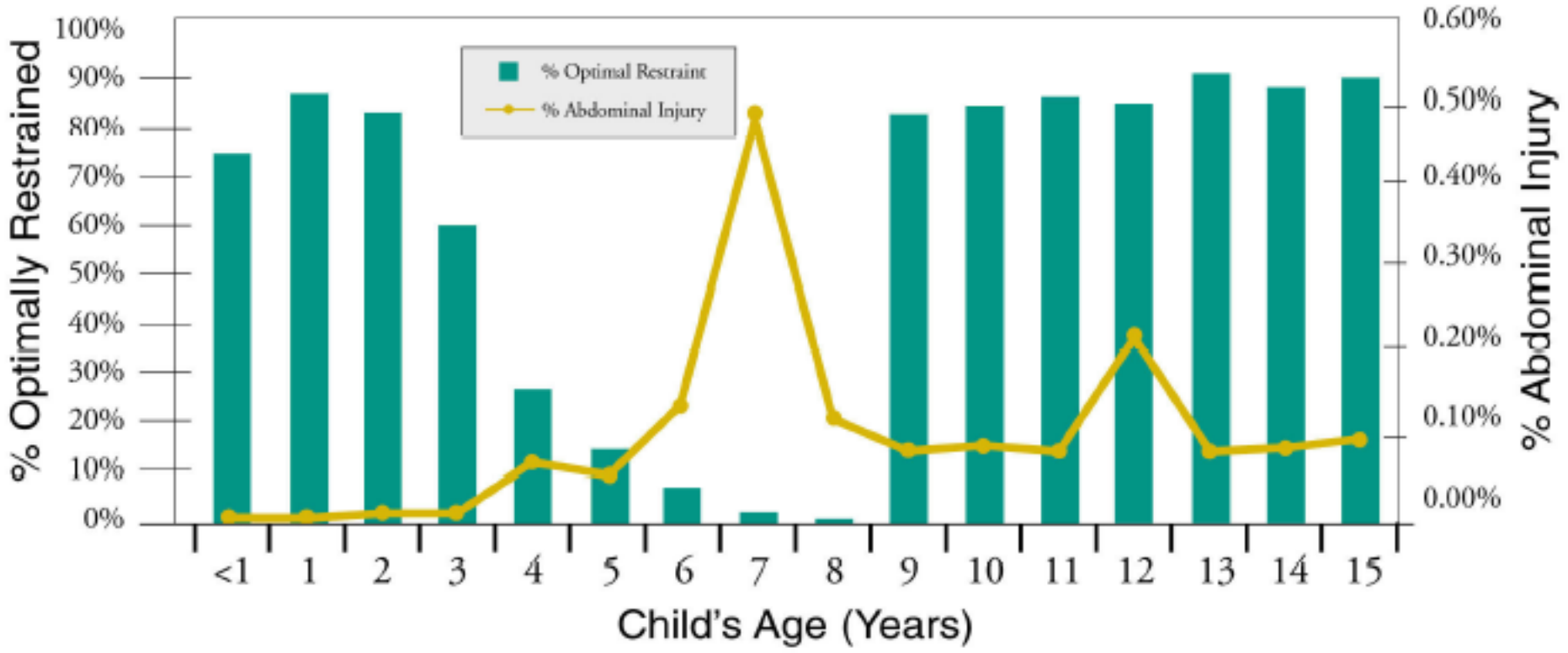
Children Don’t Fit Adult Seats

Seat Belt Mispositioning





Risk of Abdominal Injury for Child Occupants in Crashes 1999-2002

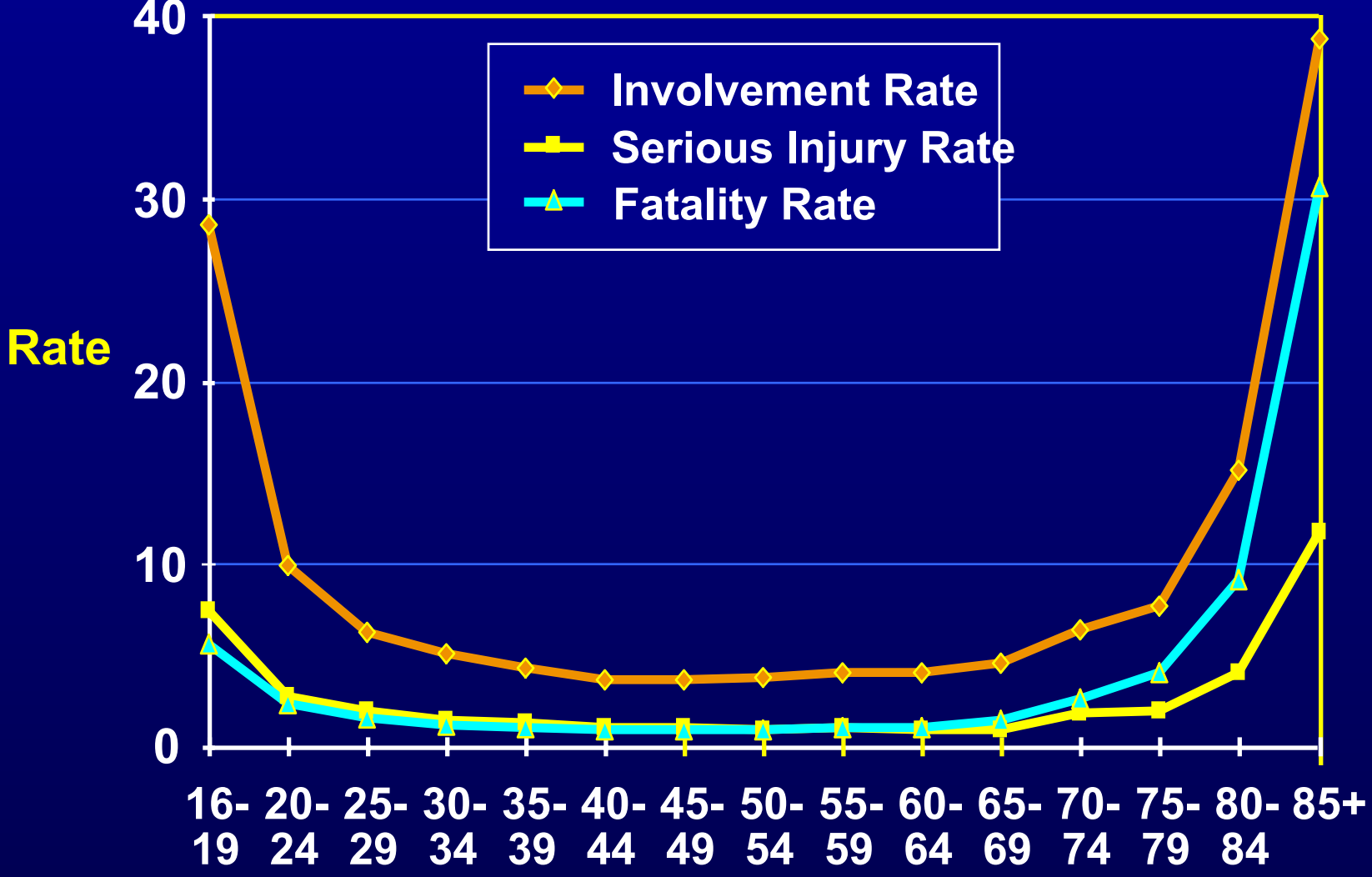


Nance ML, et al. Ann Surg. 239:127 (2004)

UMTRI

UMPIRE

Involvement, Injury, and Fatality Rates (rates per vehicle miles of travel)

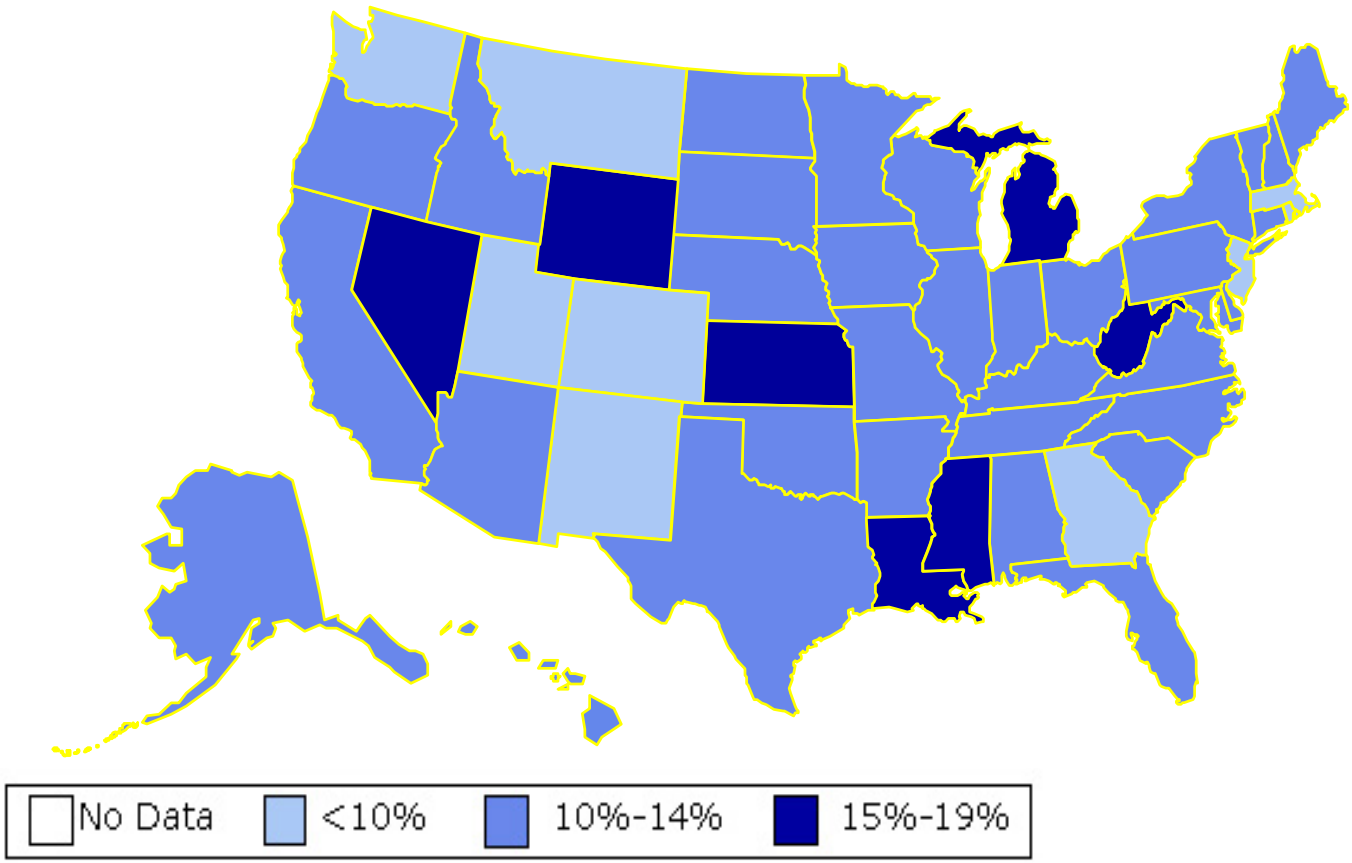


ABCs of Occupant Assessment

- **A**ge
  - Rule: The extremes of age are more vulnerable to injury (and have decreased physiologic reserve)
  - Exception: Children 3 – 8 fare poorly if not in belt-positioning booster seats.
- **B**ody Habitus
  - Rule: Size does matter – fat is protective.
  - Exception: Side impacts and LEX injuries
- **C**omplaints
  - Rule: Respiratory, neurologic, body trunk
  - Exception: Unable to complain

Obesity Trends* Among U.S. Adults
BRFSS, 1991

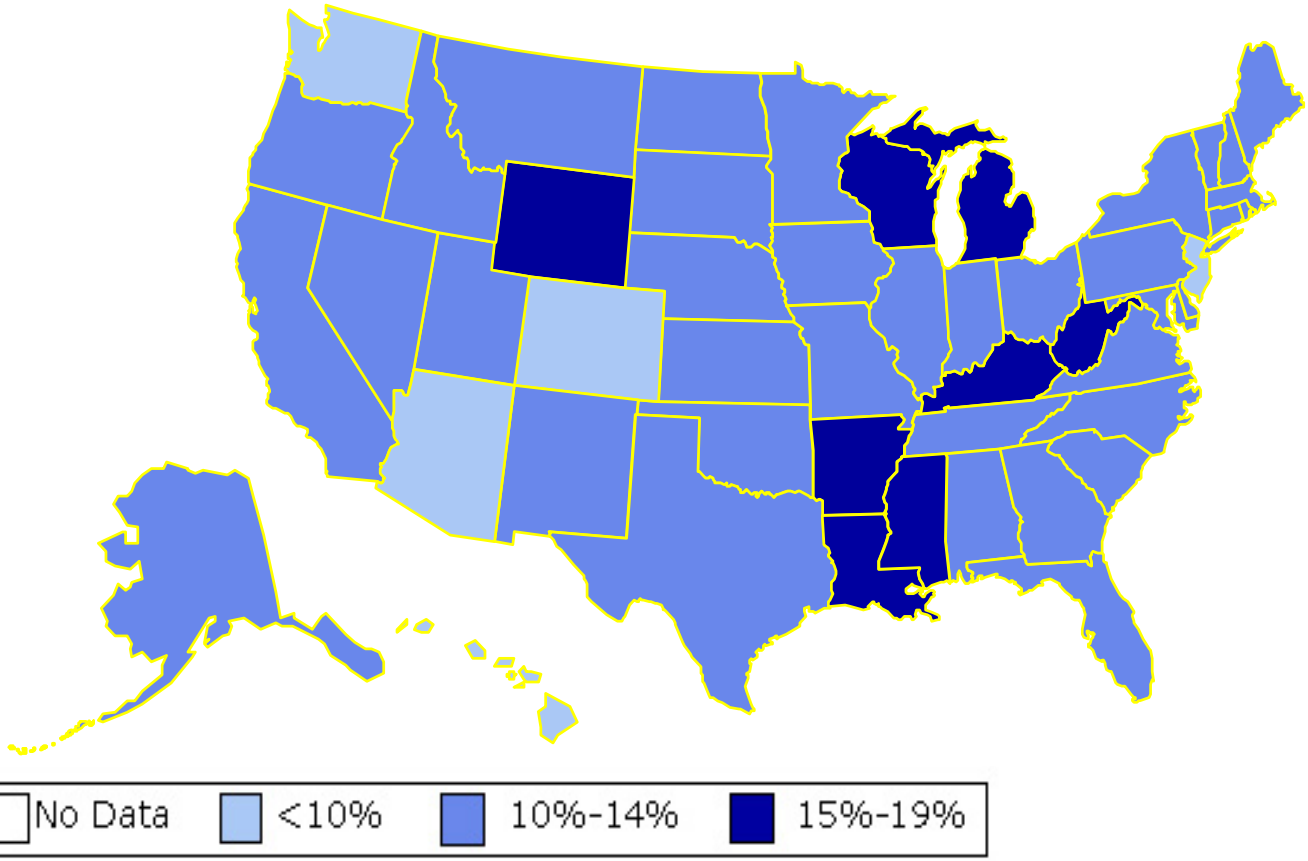
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1992

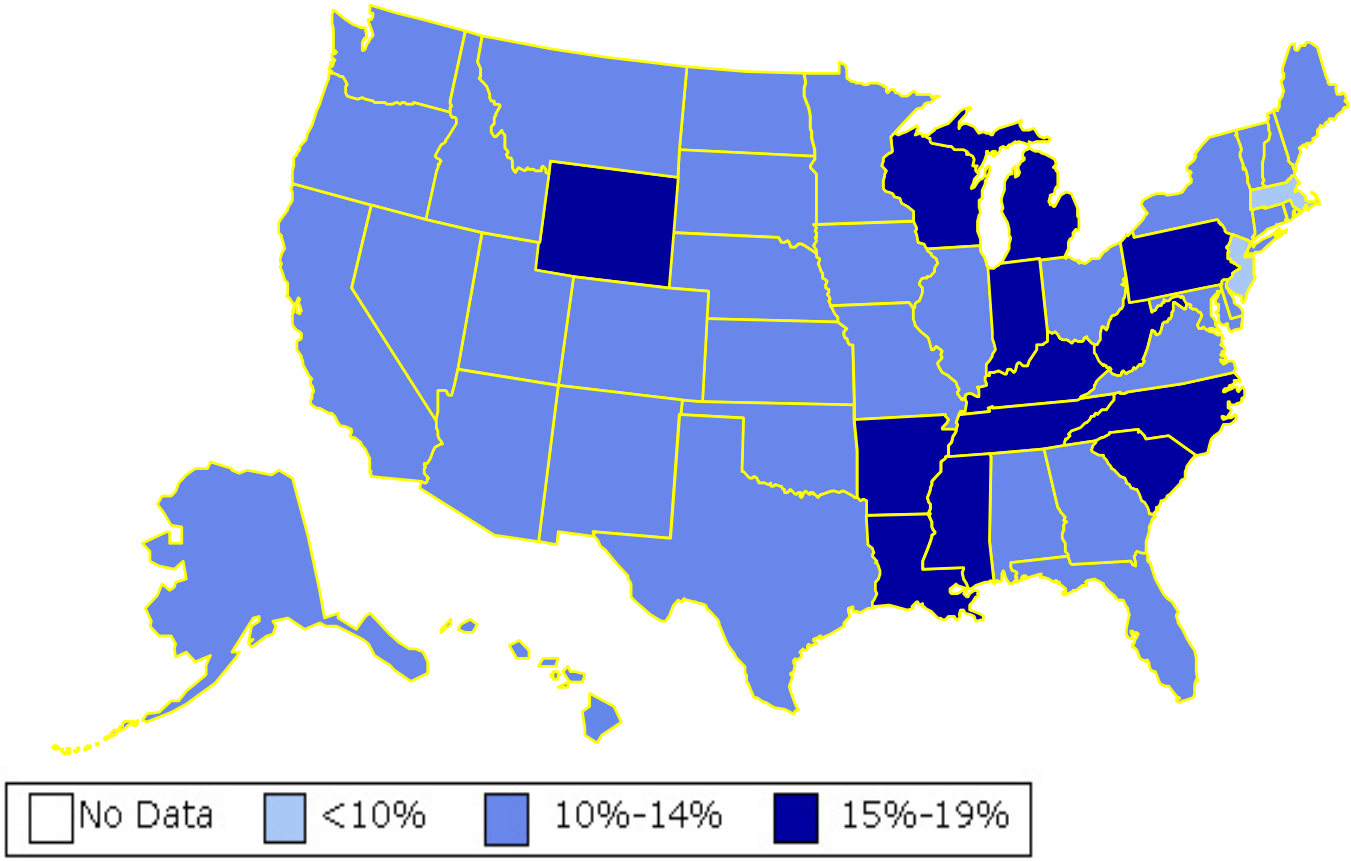
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1993

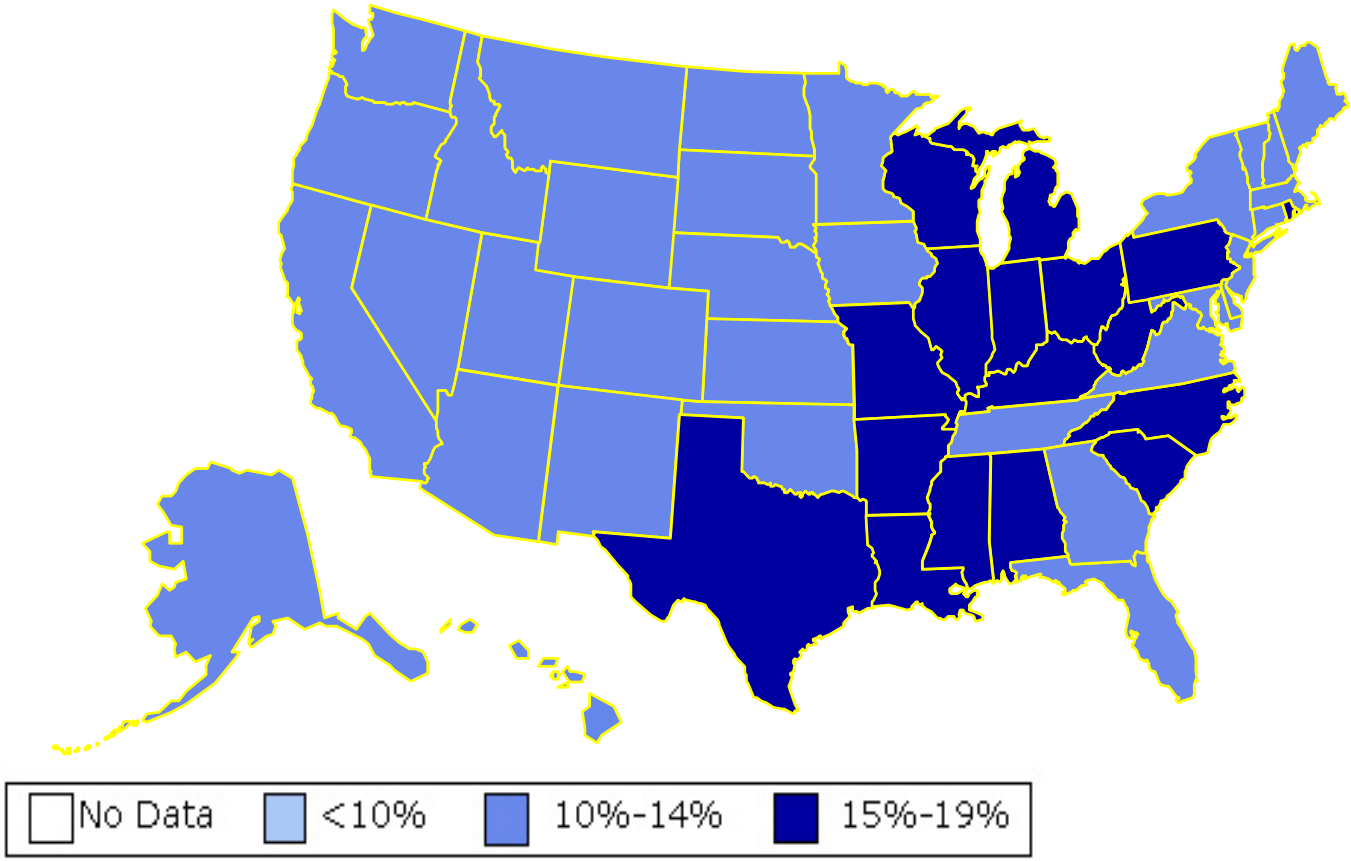
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1994

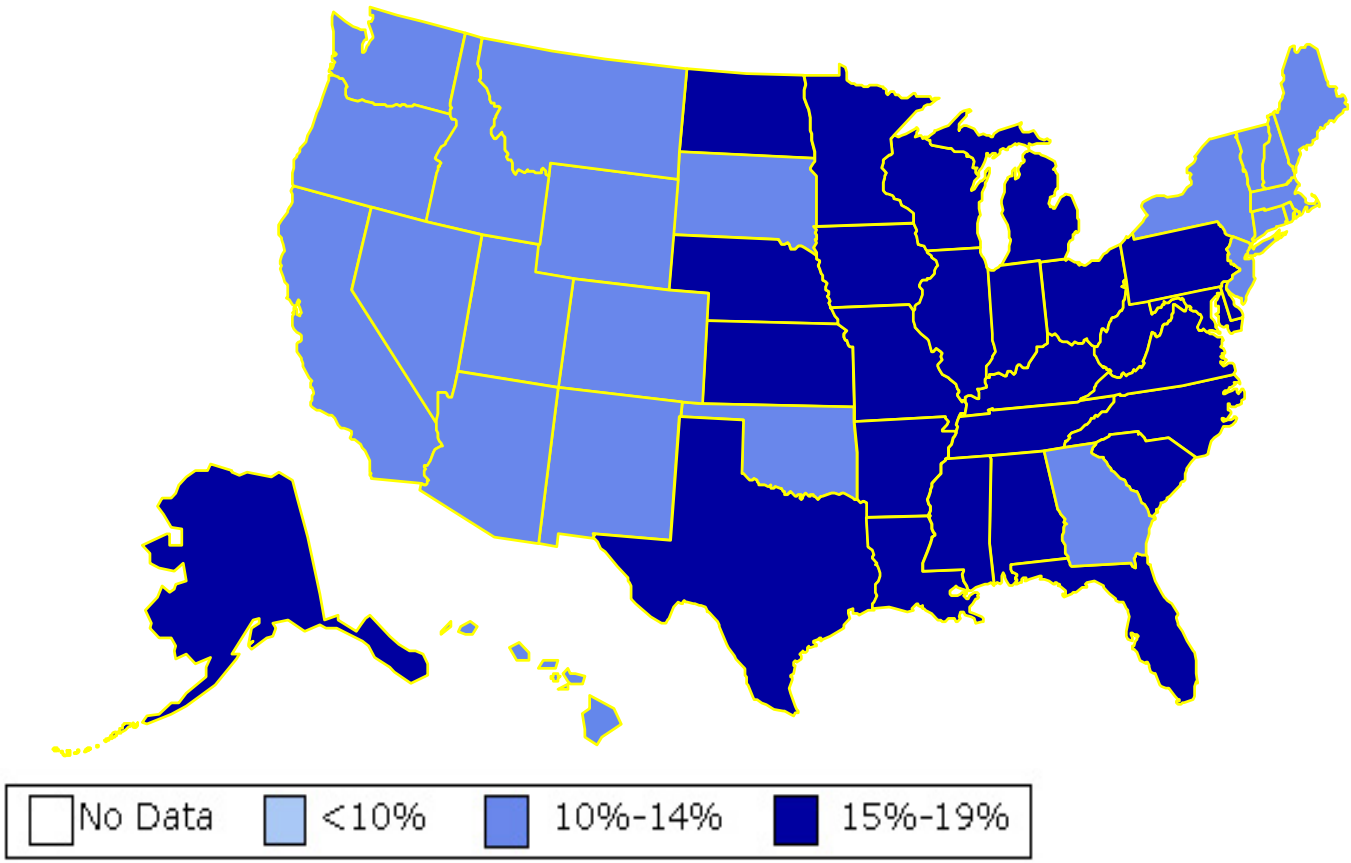
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1995

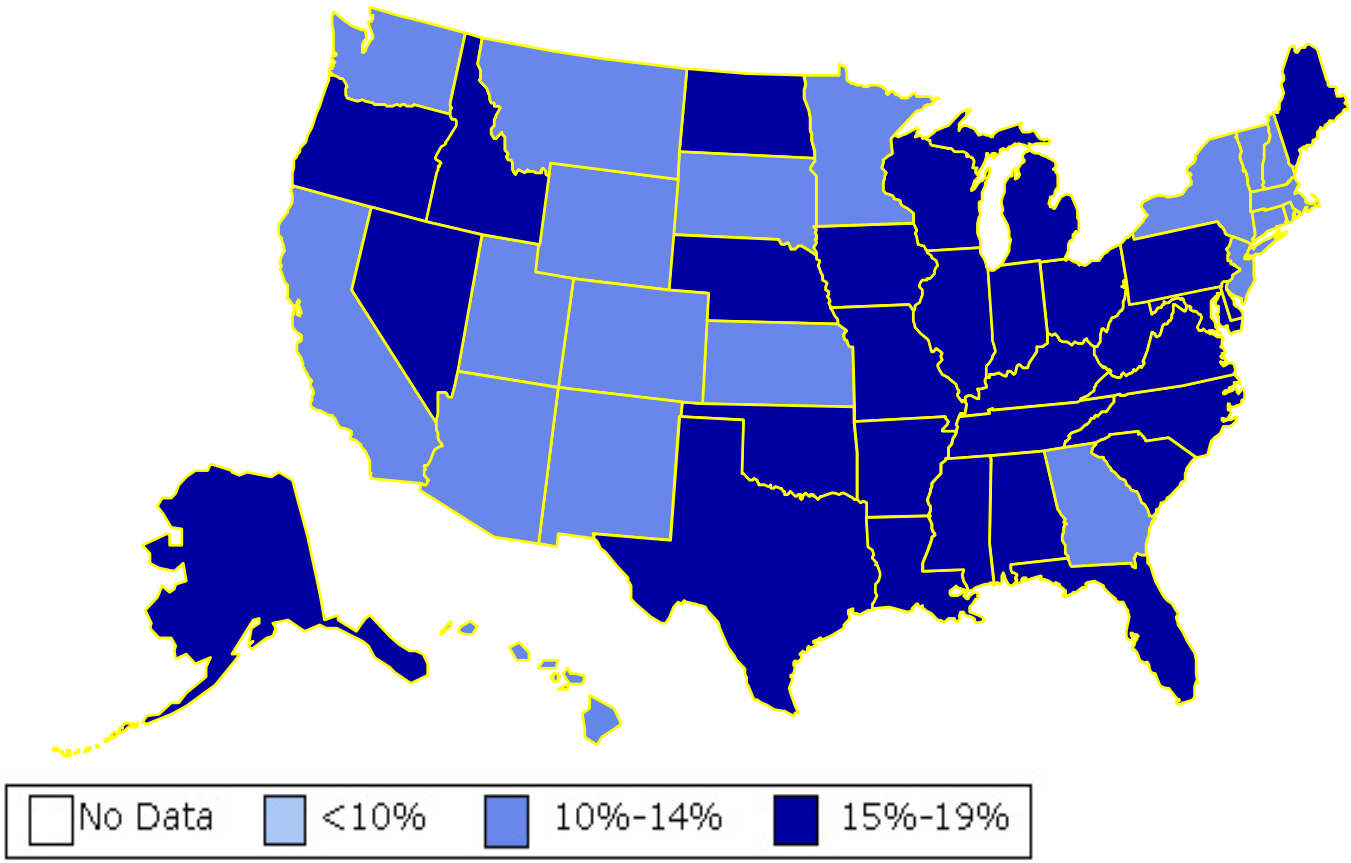
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1996

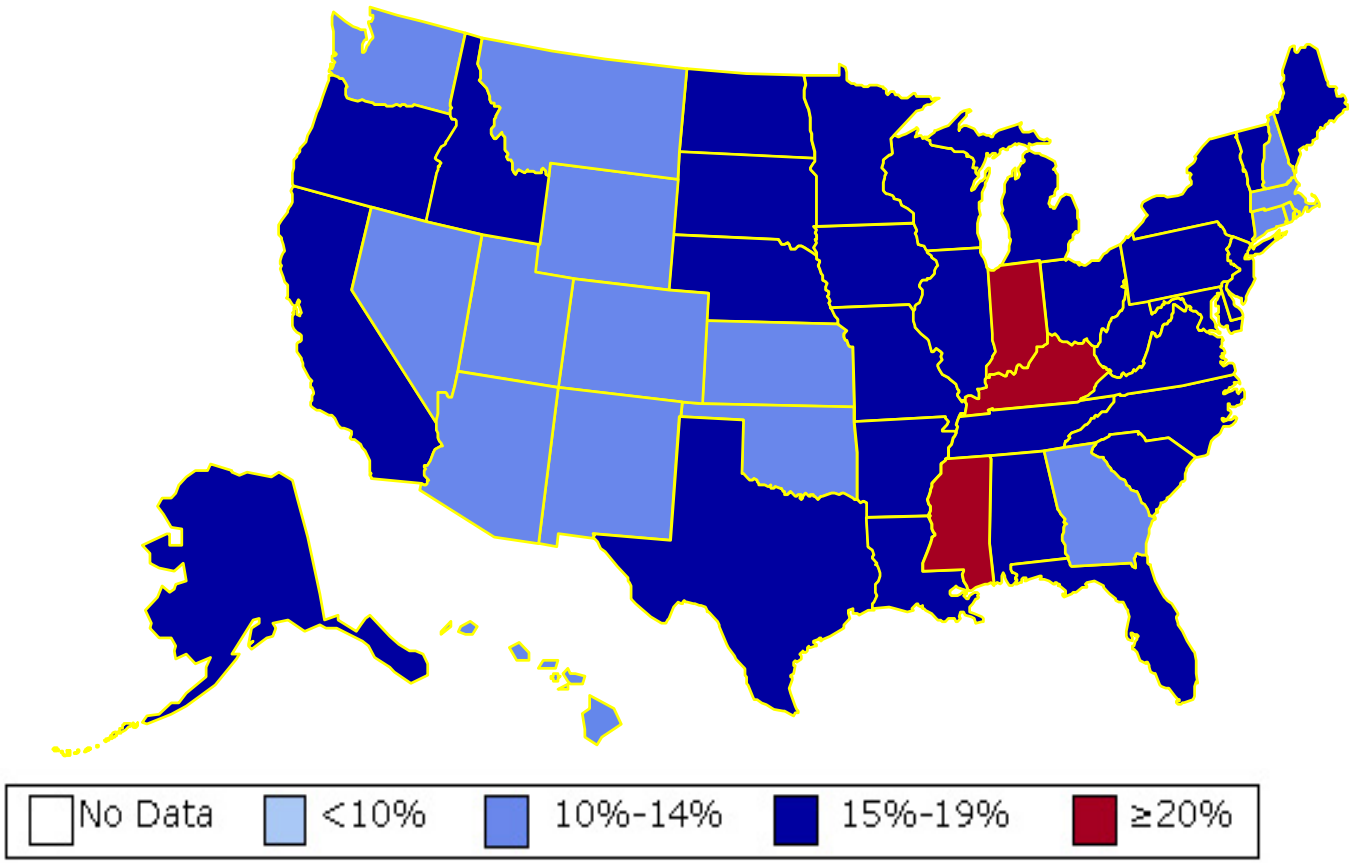
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1997

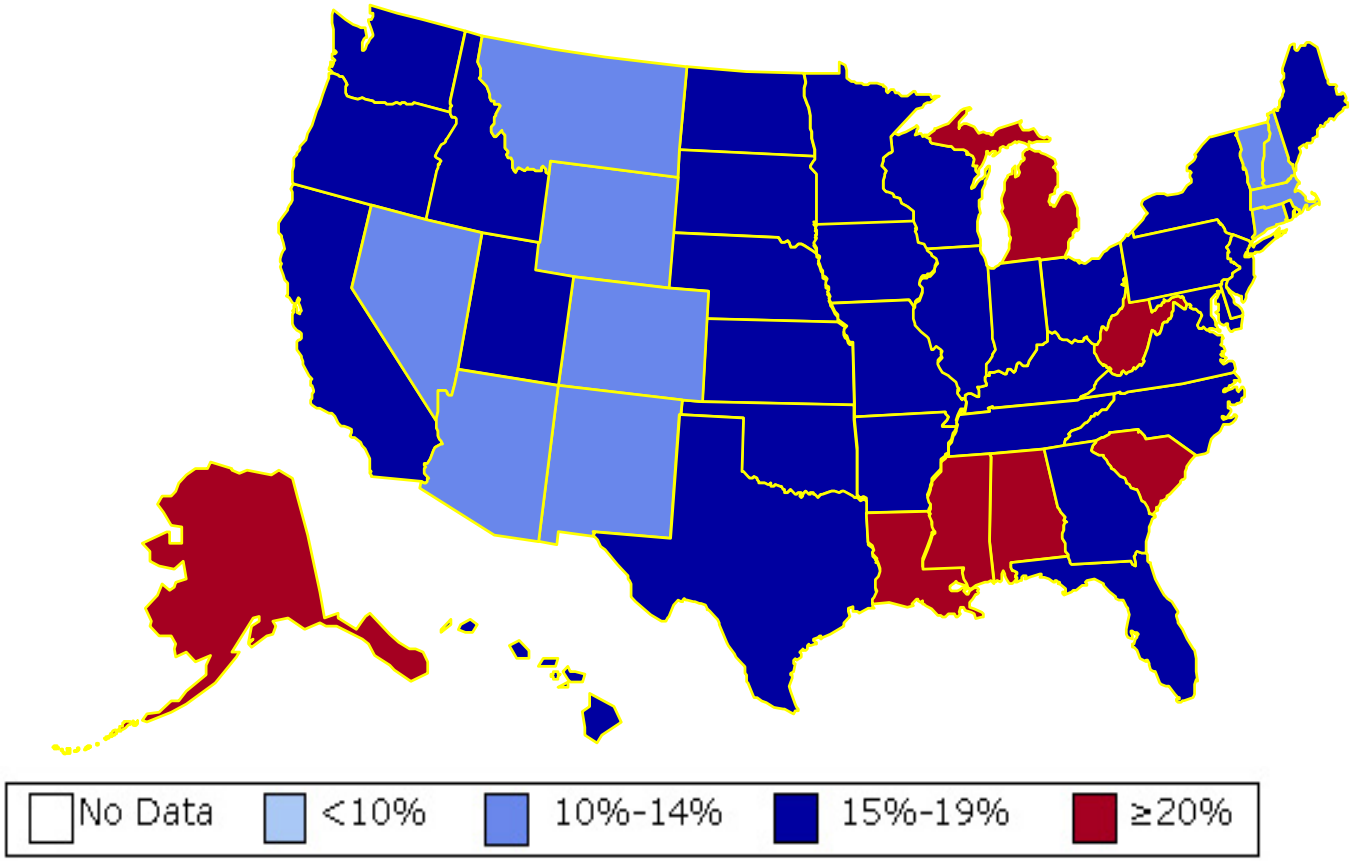
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1998

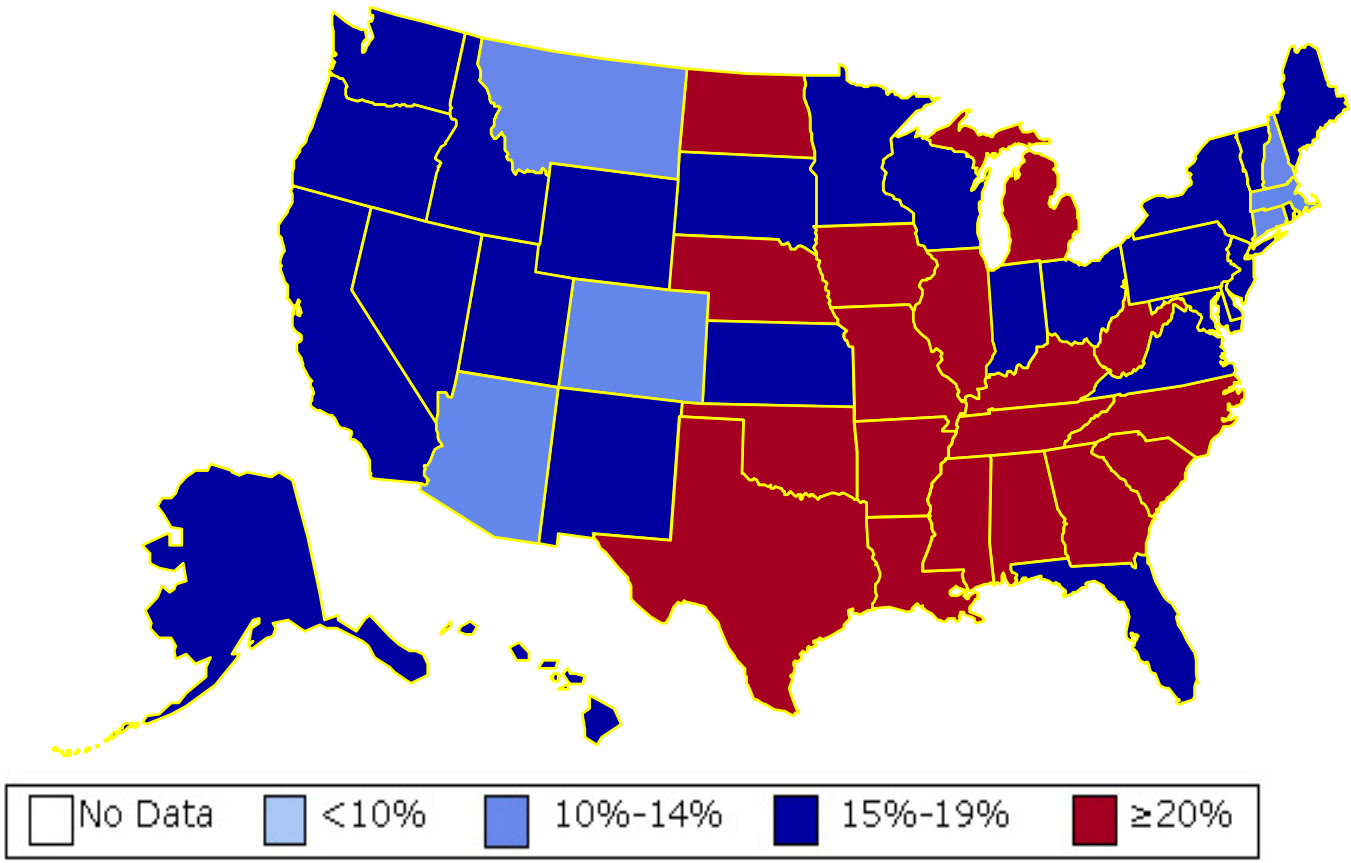
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 1999

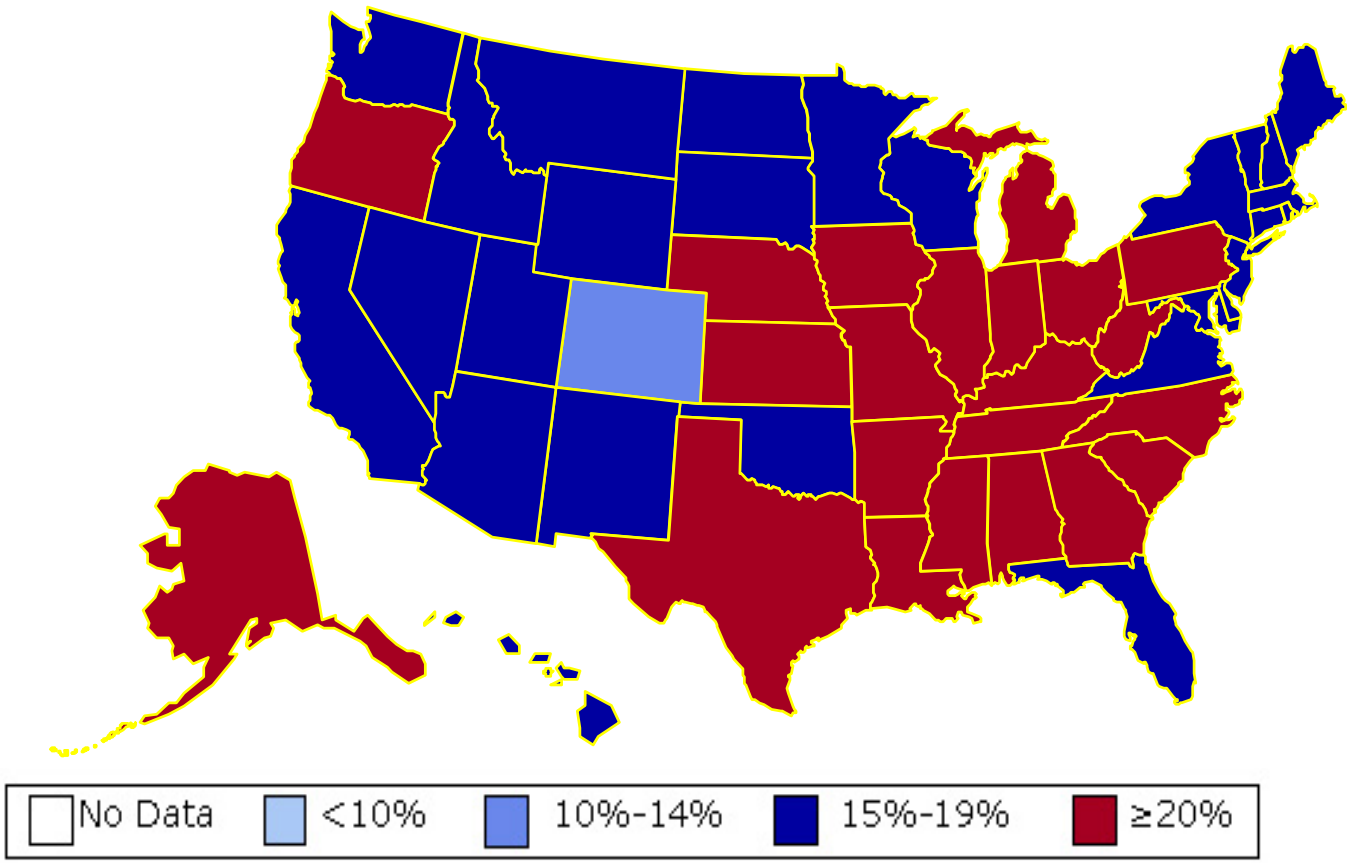
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

Obesity Trends* Among U.S. Adults
BRFSS, 2000

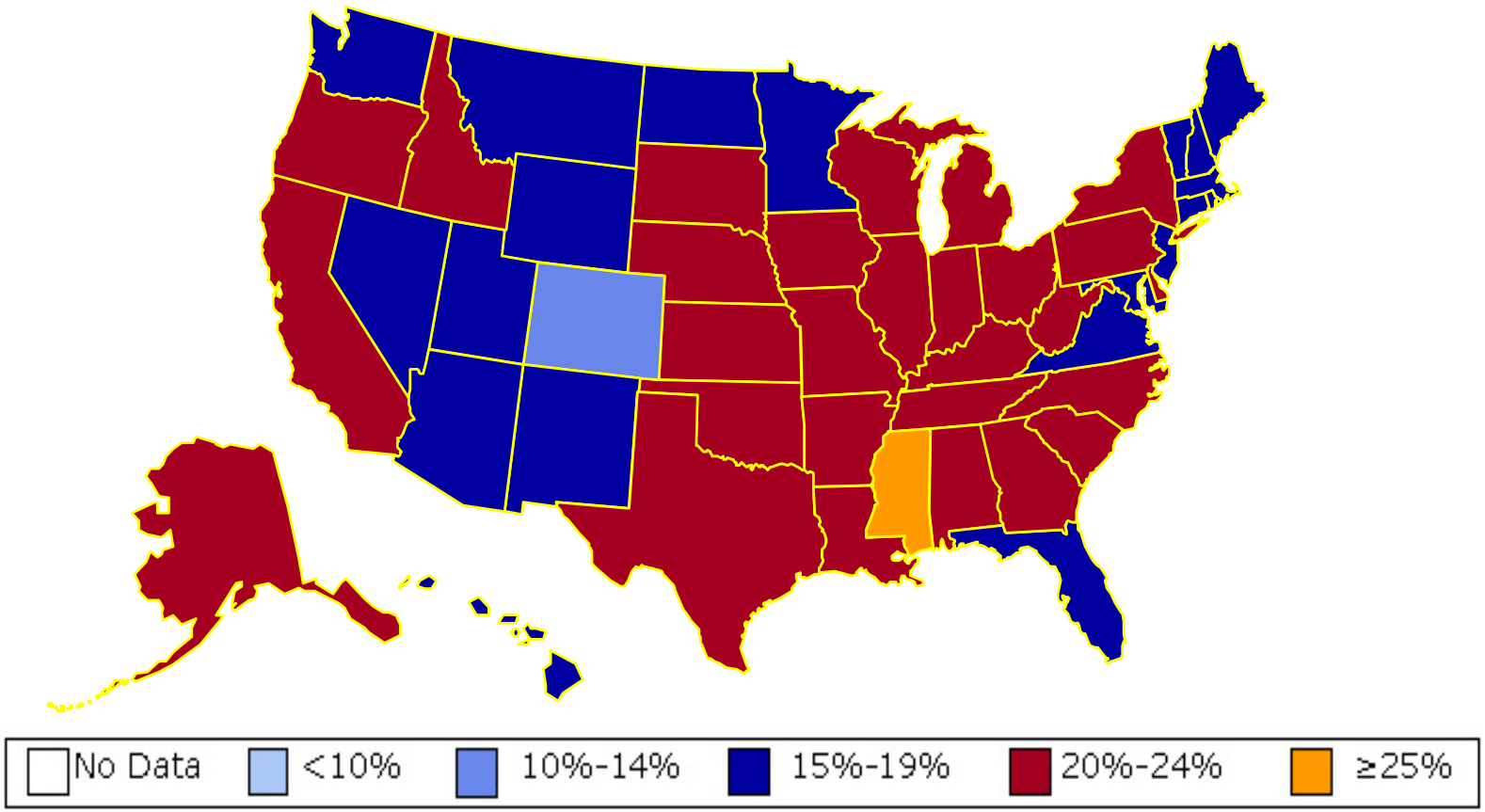
(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



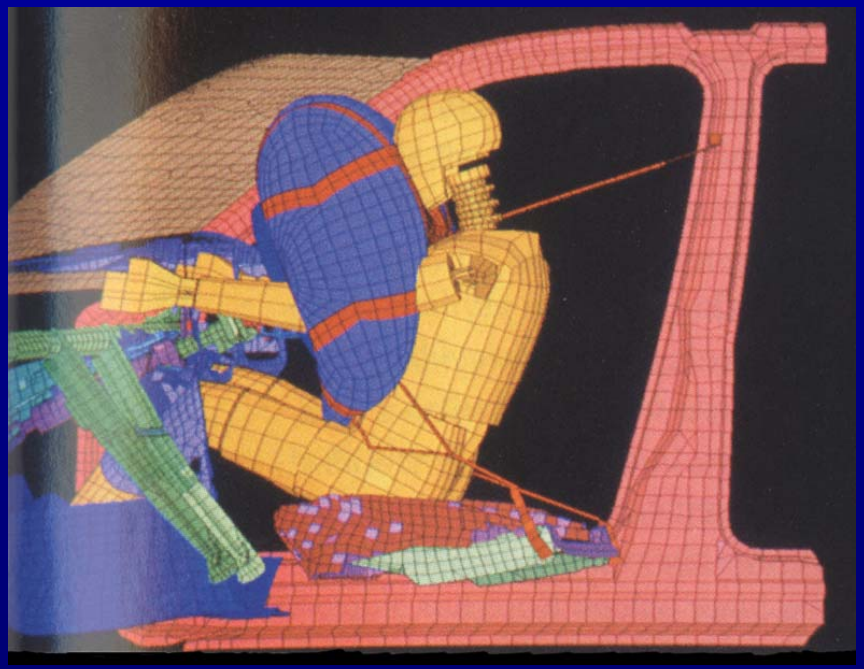
Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.

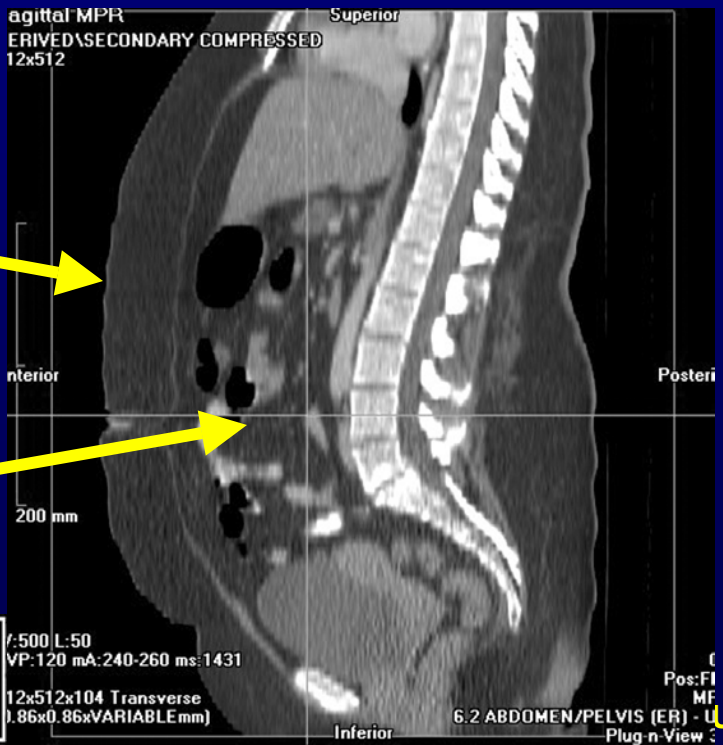
Obesity Trends* Among U.S. Adults
BRFSS, 2001

(*BMI ≥30, or ~ 30 lbs overweight for 5'4" woman)



Source: Mokdad A H, et al. *J Am Med Assoc* 1999;282:16, 2001;286:10.





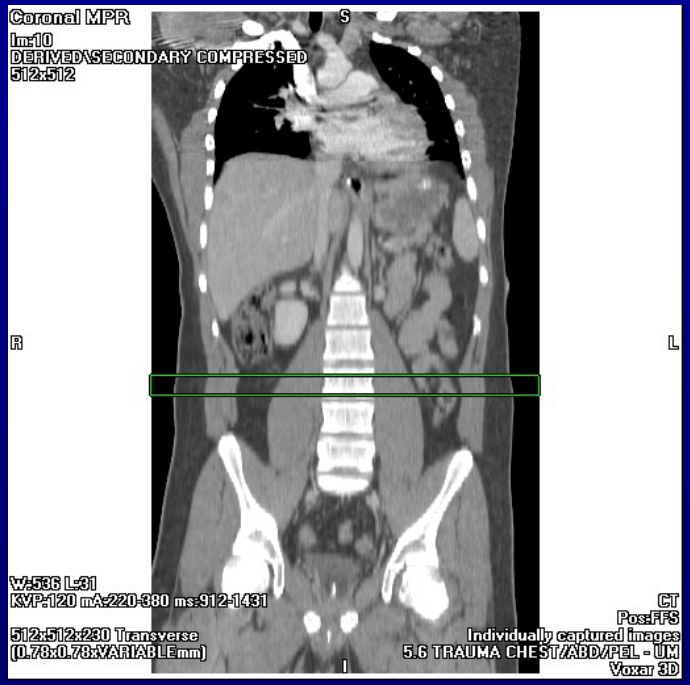
SQ

Visceral

UMTRI

UMPIRE

Study Methods



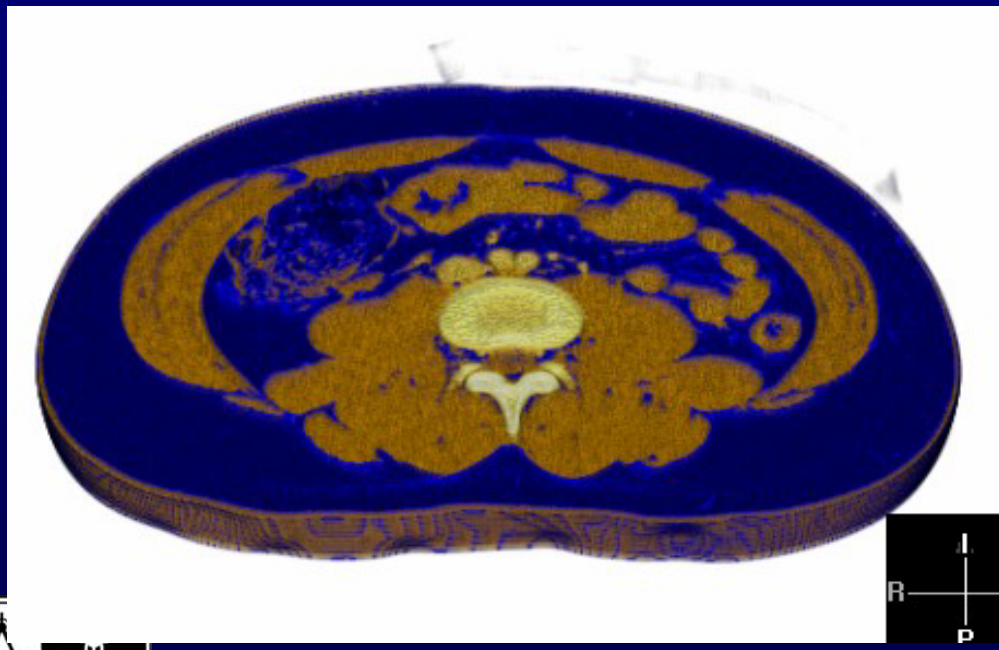
2 inch slab selected at L3

UMTRI

UMPIRE

Study Methods

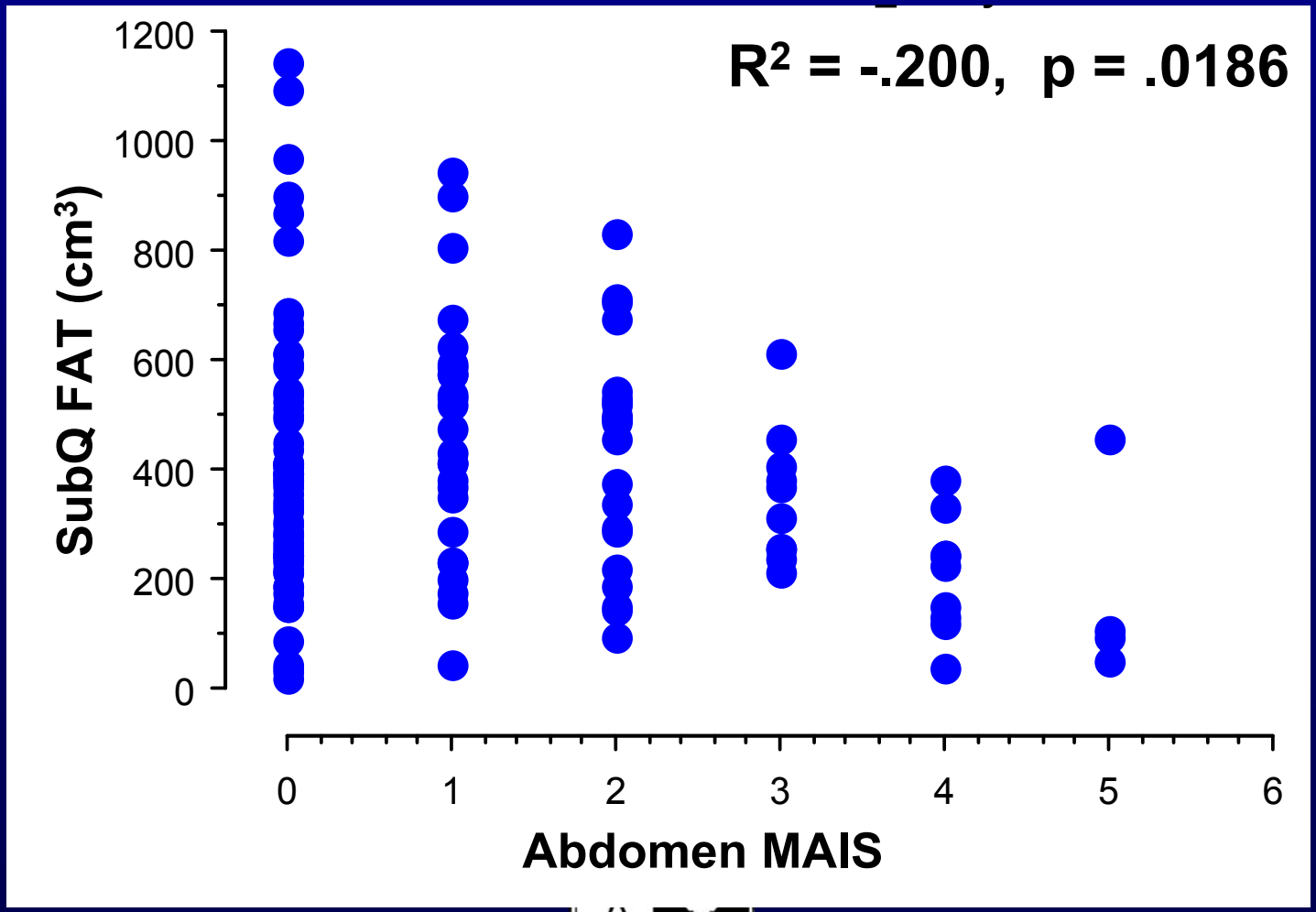
SubQ and Visceral Fat selected
and volumes measured



All subjects: Correlation between fat volume and physical and outcome factors

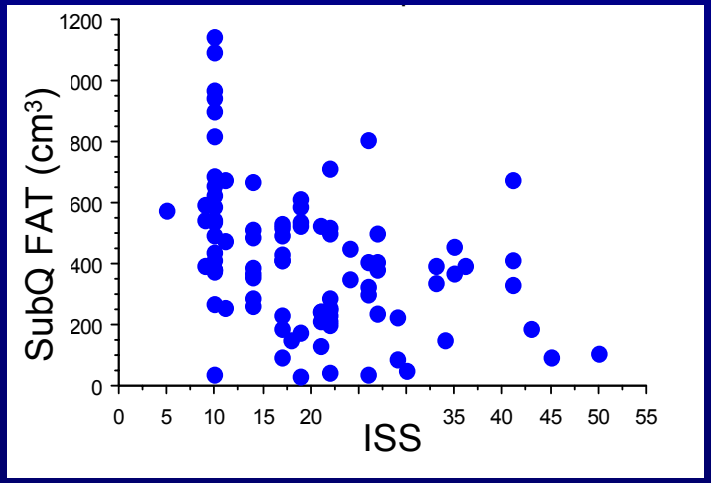
	Subcutaneous Fat		Visceral Fat	
	Correlation	P-Value	Correlation	P-Value
Age	.127	.1364	.459	<.0001
Height	-.165	.0546	.155	.0696
Weight	.556	<.0001	.458	<.0001
BMI	.698	<.0001	.394	<.0001
ISS	-.260	.0021	-.198	.0208
MAIS Head	-.268	.0014	-.211	.0128
MAIS Thorax	-.157	.0659	-.006	.9453
MAIS Abdomen	-.200	.0186	-.067	.4378
MAIS Upper Extremity	-.023	.7887	-.075	.3797
MAIS Lower Extremity	.333	<.0001	.011	.9028

Increased Subcutaneous Fat Volume Is Associated With Decreased Abdominal Injury Severity

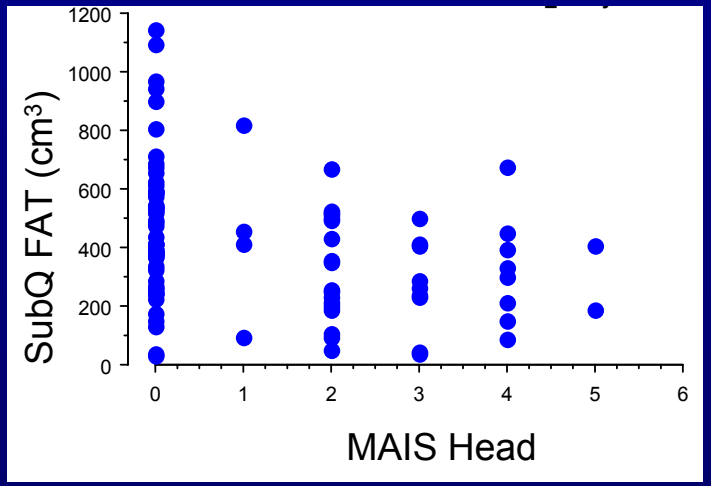


Effect of SubQ FAT on Injury Severity in Frontal Crashes

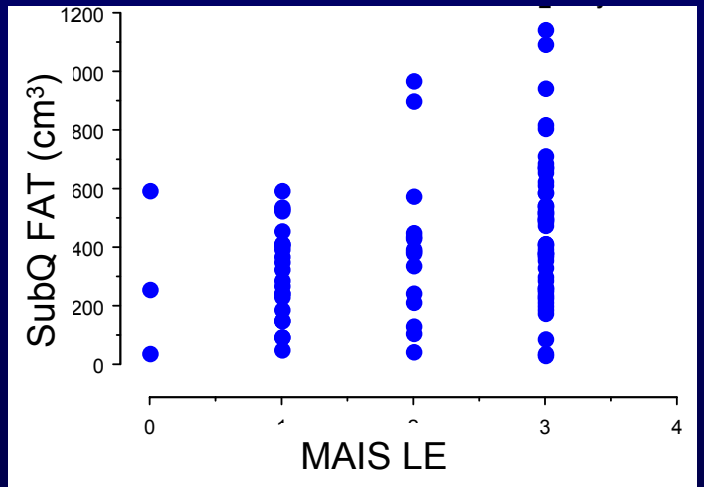
Overall



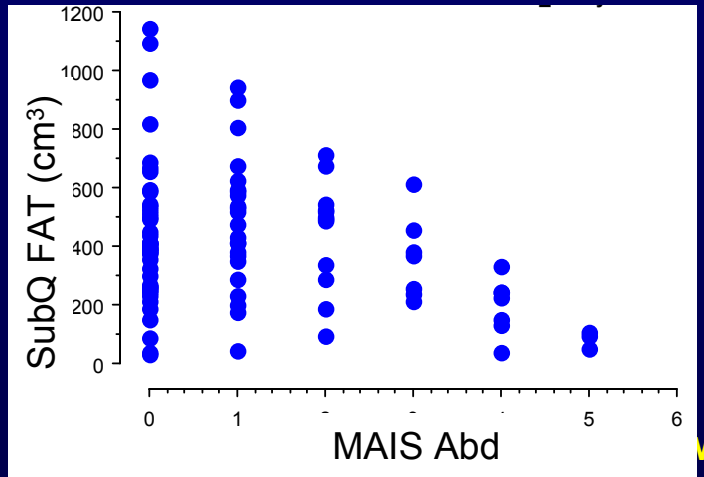
Head



Lower Extremity



Abdomen



ABCs of Occupant Assessment

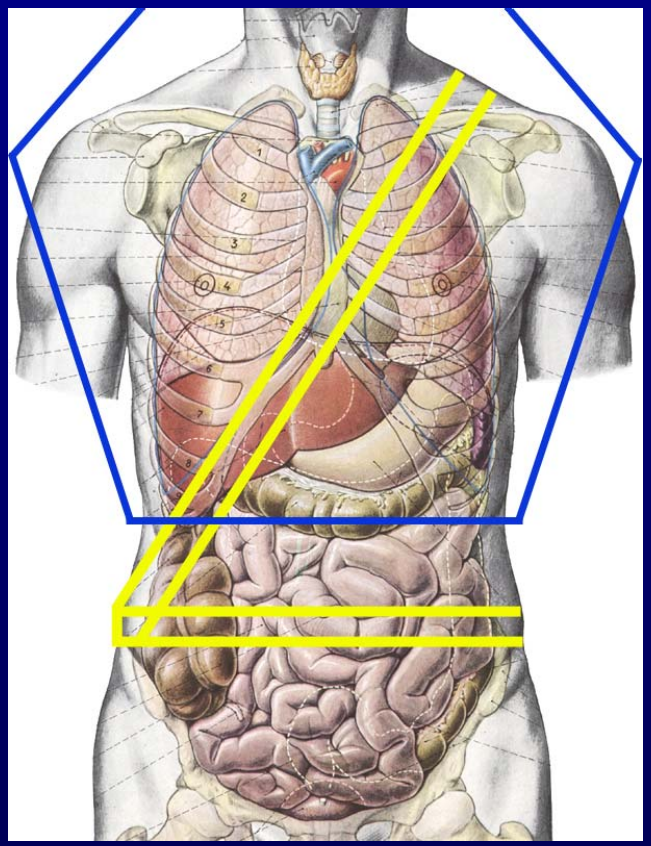
- **A**ge
  - Rule: The extremes of age are more vulnerable to injury (and have decreased physiologic reserve)
  - Exception: Children 3 – 8 fare poorly if not in belt-positioning booster seats.
- **B**ody Habitus
  - Rule: Size does matter – fat is protective.
  - Exception: Side impacts and LEX injuries
- **C**omplaints
  - Rule: Respiratory, neurologic, torso pain
  - Exception: Unable to complain

Complaints

- Respiratory
  - Airway compromise, pneumothorax, hemothorax, flail chest, diaphragm rupture
  - Secure airway and ventilation
- Neurologic
  - Spine, intracranial, cerebral-vascular
  - Spine stabilization,
- Torso pain
  - Internal visceral injuries
  - Chest decompression, access/volume, pelvic stabilization.

Frontal Collisions- Torso Injuries

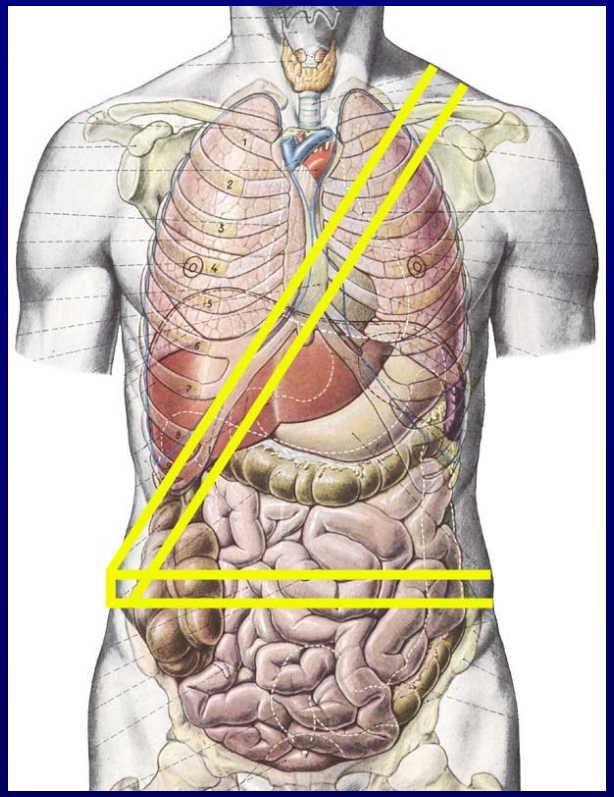
- Lateral rib fractures
  - Visceral Injuries evenly distributed
  - Lung, liver, spleen
- Intestinal - seatbelt
- Pelvic fractures
  - open book, posterior hip dislocation



Side Impact Collisions- Torso Injuries

Greater risk of injury than frontal

- **Posterior rib fractures**
- **Struck side visceral injuries**
  - lung, liver, spleen, *kidney*
- **Diaphragm and aortic injuries common (Left)**
- **Pelvic fractures - central acetabular**



Risk of chest, neck and head injuries increases with height of striking object

ABCs of Occupant Assessment

- **A**ge
  - Rule: The extremes of age are more vulnerable to injury (and have decreased physiologic reserve)
  - Exception: Children 3 – 8 fare poorly if not in belt-positioning booster seats.
- **B**ody Habitus
  - Rule: Size does matter – fat is protective.
  - Exception: Side impacts and LEX injuries
- **C**omplaints
  - Rule: Respiratory, neurologic, torso pain
  - Exception: Unable to complain