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# Child Occupant Protection: Latest Knowledge and Future Opportunities

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Center for Injury Research and Prevention  
The Children's Hospital of Philadelphia

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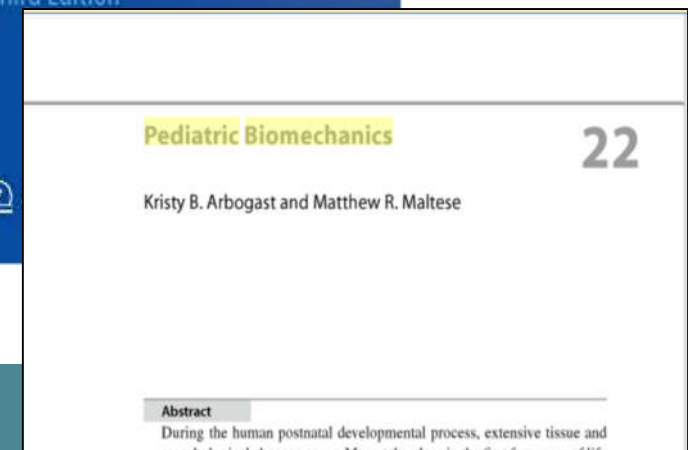
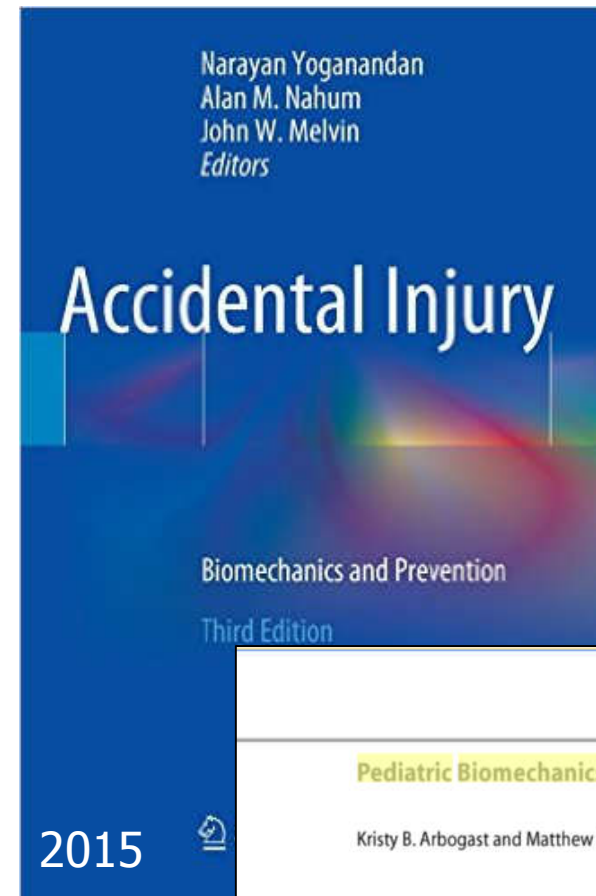
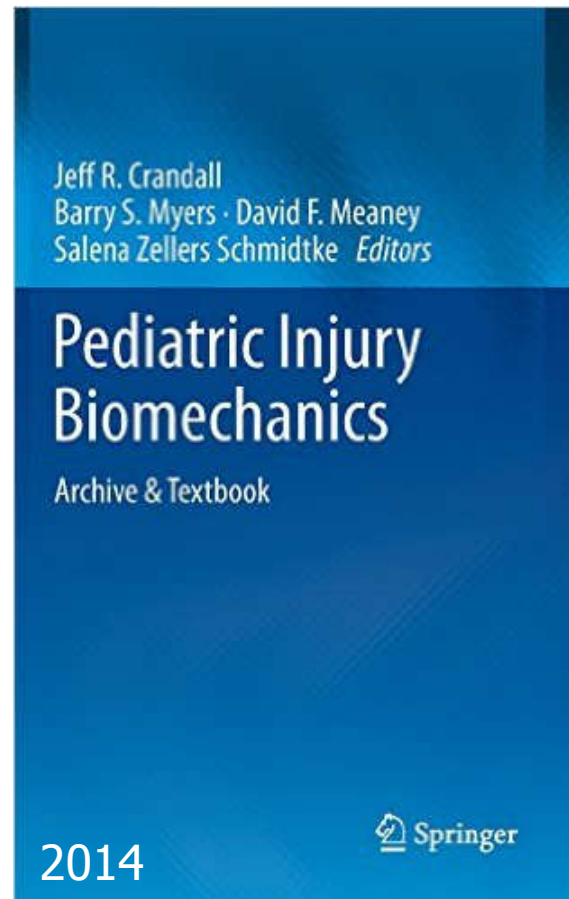
# Problem Facing our Youth

## Leading Causes of Death by Age Group

< 1year	1-4 years	5-14 years	15-29 years
Preterm birth complications	Malaria	Road Injury	Road Injury
Lower respiratory infections	Lower respiratory infections	HIV/AIDS	Interpersonal violence
Neonatal encephalopathy	Diarrheal diseases	Diarrheal diseases	Self-harm
Neonatal sepsis	Malnutrition	Lower respiratory infections	HIV/AIDS
Diarrheal diseases	HIV/AIDS	Malaria	Tuberculosis
Congenital anomalies	Drowning	Drowning	Drowning
Malaria	Meningitis	Typhoid fevers	Malaria
Meningitis	Road Injury	Meningitis	Lower respiratory infections
Malnutrition	Measles	Congenital anomalies	Mechanical forces
Syphilis	Fire	Forces of nature	Diarrheal diseases



# Quantify Fundamental Mechanics of Children





# Develop Pediatric Specific Tools



*Annals of Biomedical Engineering*, Vol. 41, No. 12, December 2013 (© 2013) pp. 2538–2552  
DOI: 10.1007/s10439-013-0858-7



## Development and Validation of a 10-Year-Old Child Ligamentous Cervical Spine Finite Element Model

LIQIANG DONG,<sup>1,2</sup> GUANGYAO LI,<sup>1</sup> HAOJIE MAO,<sup>2</sup> STANLEY MAREK,<sup>2</sup> and KING H. YANG<sup>2</sup>

## INJURY SIMULATION OF REAR SEAT CHILD OCCUPANT IN OFFSET DEFORMABLE BARRIER FRONTAL IMPACT

Tomoshi Takahashi  
Satoshi Fukushima  
Yuichi Kitagawa  
Tsuyoshi Yasuki  
Toyota Motor Corporation  
Japan

IRC-15-73

IRCOBI Conference 2015

## Development and a Limited Validation of a Whole-Body Finite Element Pedestrian and Occupant Models of a 10-Year-Old Child

Ming Shen<sup>1</sup>, Feng Zhu, Binhui Jiang, Vikas Sanghavi, Haonan Fan, Yun Cai, Zhenguang Wang, Anil Kalra, Xin Jin, Clifford C. Chou, King H. Yang

IRC-15-74

## Development of an Active 6-Year-Old Child Human Body Model for Simulation of Emergency Events

Karin Brolin<sup>1</sup>, Isabelle Stockman<sup>1</sup>, Hariharan Subramanian<sup>2</sup>, Laure-Lise Gras<sup>1</sup>, Jonas Östh<sup>1</sup>

<sup>1</sup> Chalmers University of Technology, Gothenburg, Sweden. <sup>2</sup> Indian Institute of Technology, Delhi, India.



# Stimulate development of engineering strategies for rear seat protection

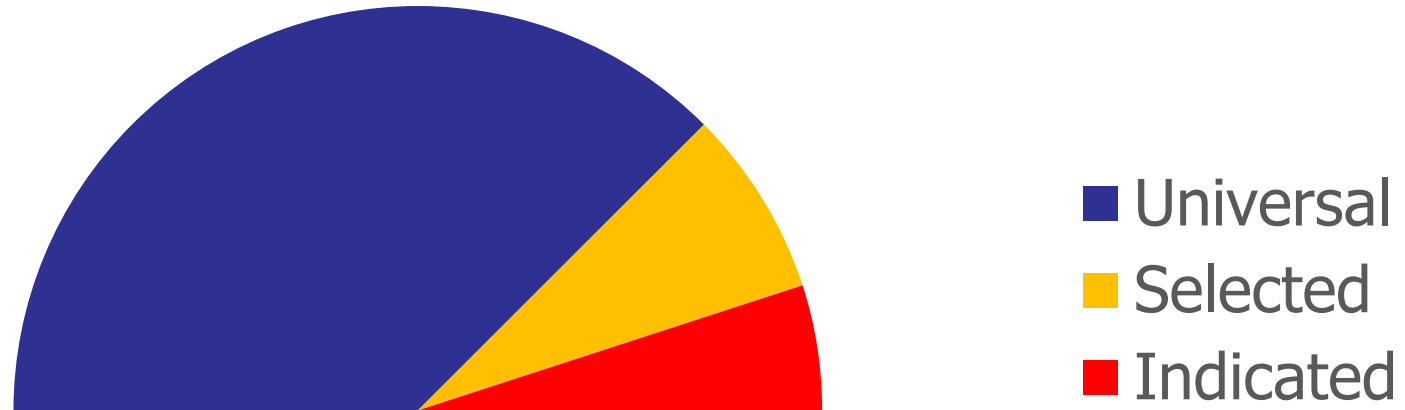


From latest EuroNCAP news release...

*"Almost all new cars in this release ... have incorporated more advanced restraint technology on the rear seats to cope with the newest full-width frontal crash test."*



# “Precision Prevention” – tiered risk



UNIVERSAL	SELECTED	INDICATED
Typical risk Tailored to population	Individual with known risk factors	Individual with unsafe behaviors or crashes



right STRATEGY  
right PERSON  
right TIME  
right CIRCUMSTANCE



# Best Practice Recommendations Based on Biomechanical Principles

Using the correct car seat or booster seat can be a lifesaver: make sure your child is always buckled in an age- and size-appropriate car seat or booster seat.



## REAR-FACING CAR SEAT

**Birth up to Age 2\***  
Buckle children in a rear-facing seat until age 2 or when they reach the upper weight or height limit of that seat.



## FORWARD-FACING CAR SEAT

**Age 2 up to at least age 5\***  
When children outgrow their rear-facing seat, they should be buckled in a forward-facing car seat until at least age 5 or when they reach the upper weight or height limit of that seat.



## BOOSTER SEAT

**Age 5 up until seat belts fit properly\***  
Once children outgrow their forward-facing seat, they should be buckled in a booster seat until seat belts fit properly. The recommended height for proper seat belt fit is 57 inches tall.



## SEAT BELT

**Once seat belts fit properly without a booster seat**  
Children no longer need to use a booster seat once seat belts fit them properly. Seat belts fit properly when the lap belt lays across the upper thighs (not the stomach) and the shoulder belt lays across the

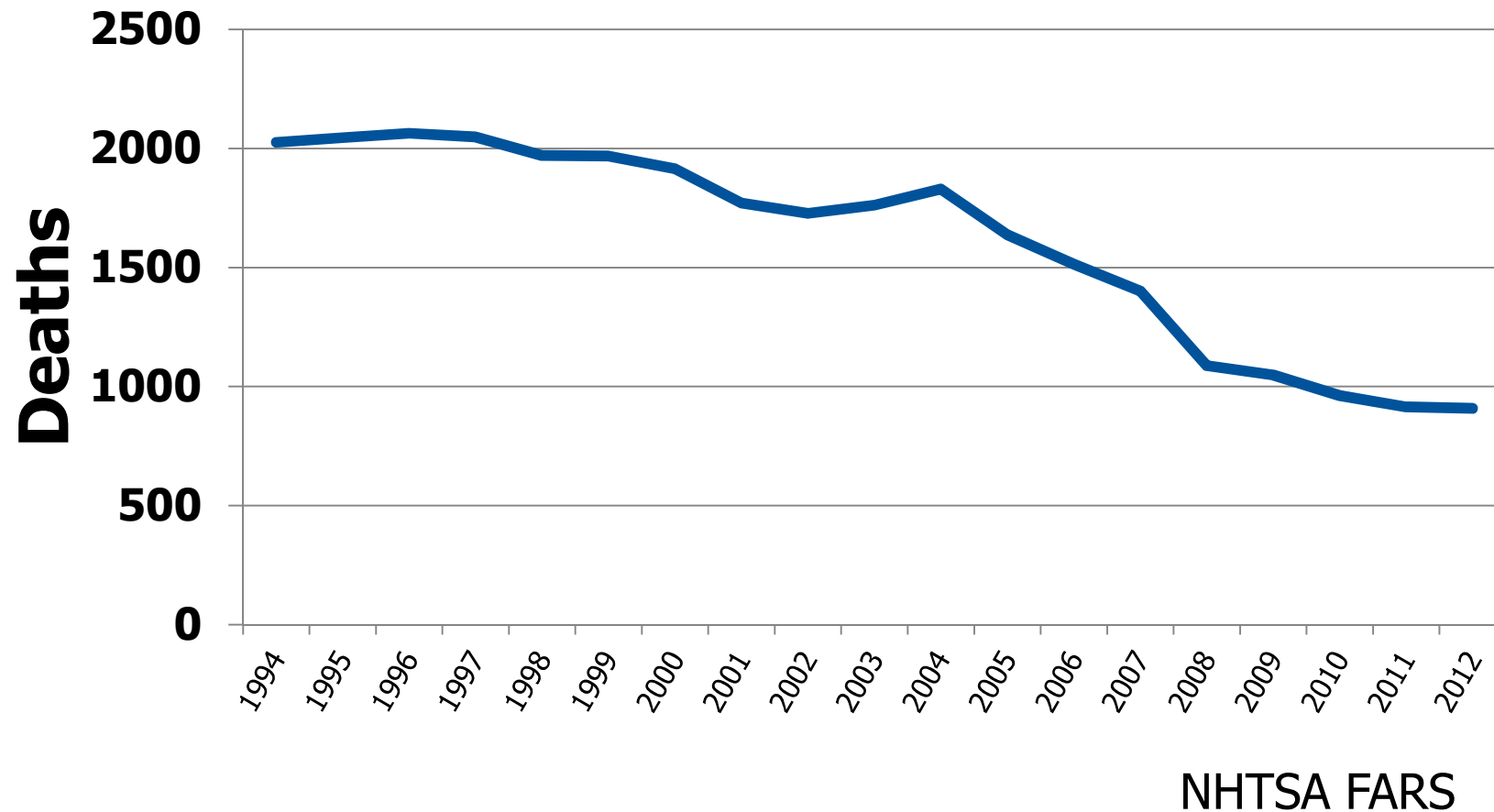
Keep children ages 12 and under in the back seat. Never p

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# Impact: Crash Fatalities

>50% reduction in deaths to children < 16

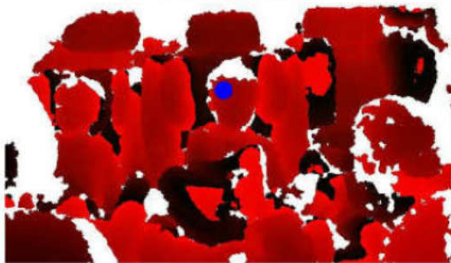




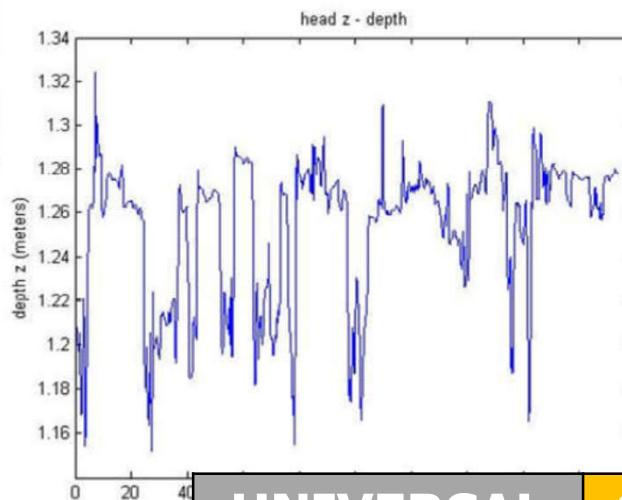
# Define realistic postures and positions

Charlton et al with US & Swedish colleagues

- Large naturalistic driving study rear row occupants (42 families, 690 hrs of data)
- Head position tracked via Kinect motion tracking



- Depth of head motion quantified



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# Define realistic postures and positions

Charlton et al with US & Swedish colleagues

- Large naturalistic driving study rear row occupants (42 families, 690 hrs of driving)
- Head positions



IRC-13-105

IRCOBI Conference 2013

Older Children's Sitting Postures, Behaviour and Comfort Experience during Ride – A Comparison between an Integrated Booster Cushion and a High-Back Booster

Anna-Lisa Osvalder, Ida Hansson, Isabelle Stockman, Anna Carlsson,  
Katarina Bohman, Lotta Jakobsson



*Traffic Injury Prevention* (2014) 15, 866–874  
Copyright © Taylor & Francis Group, LLC  
ISSN: 1538-9588 print / 1538-957X online  
DOI: 10.1080/15389588.2014.890720



Kinematics of Pediatric Crash Dummies Seated on Vehicle Seats with Realistic Belt Geometry

KATHLEEN D. KLINICH<sup>1</sup>, MATT

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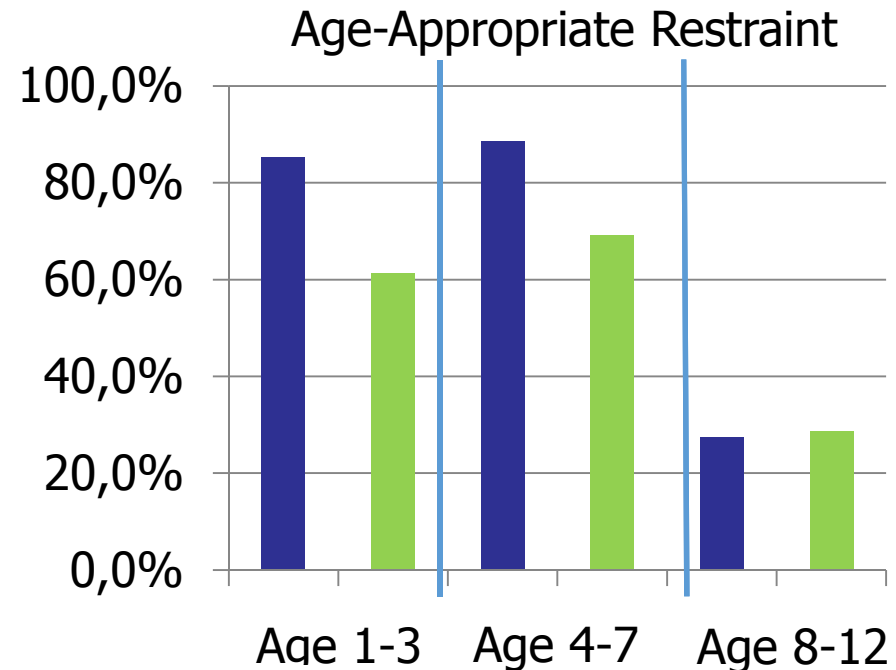


# Need NEW Approach for Targeted Populations

White parents had higher adjusted odds of reported age-appropriate restraint for their children

OR 3.86, 95% CI 2.27–6.57\*

\*controlling for education, income, information sources, and site



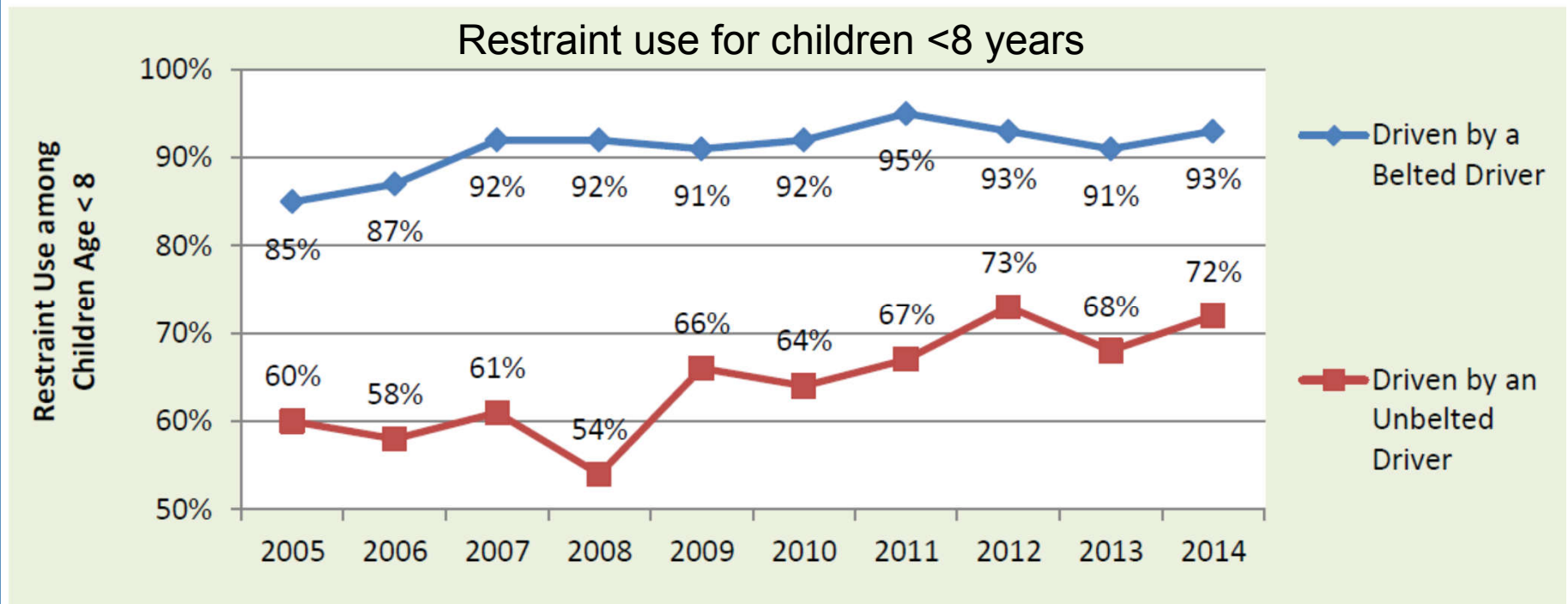
White Non-White

Macy et al. *Pediatrics*, 2014

UNIVERSAL	SELECTED	INDICATED
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# Restrained drivers lead to restrained children – increase adult restraint use



DOT HS 812 244

**UNIVERSAL**

Typical risk  
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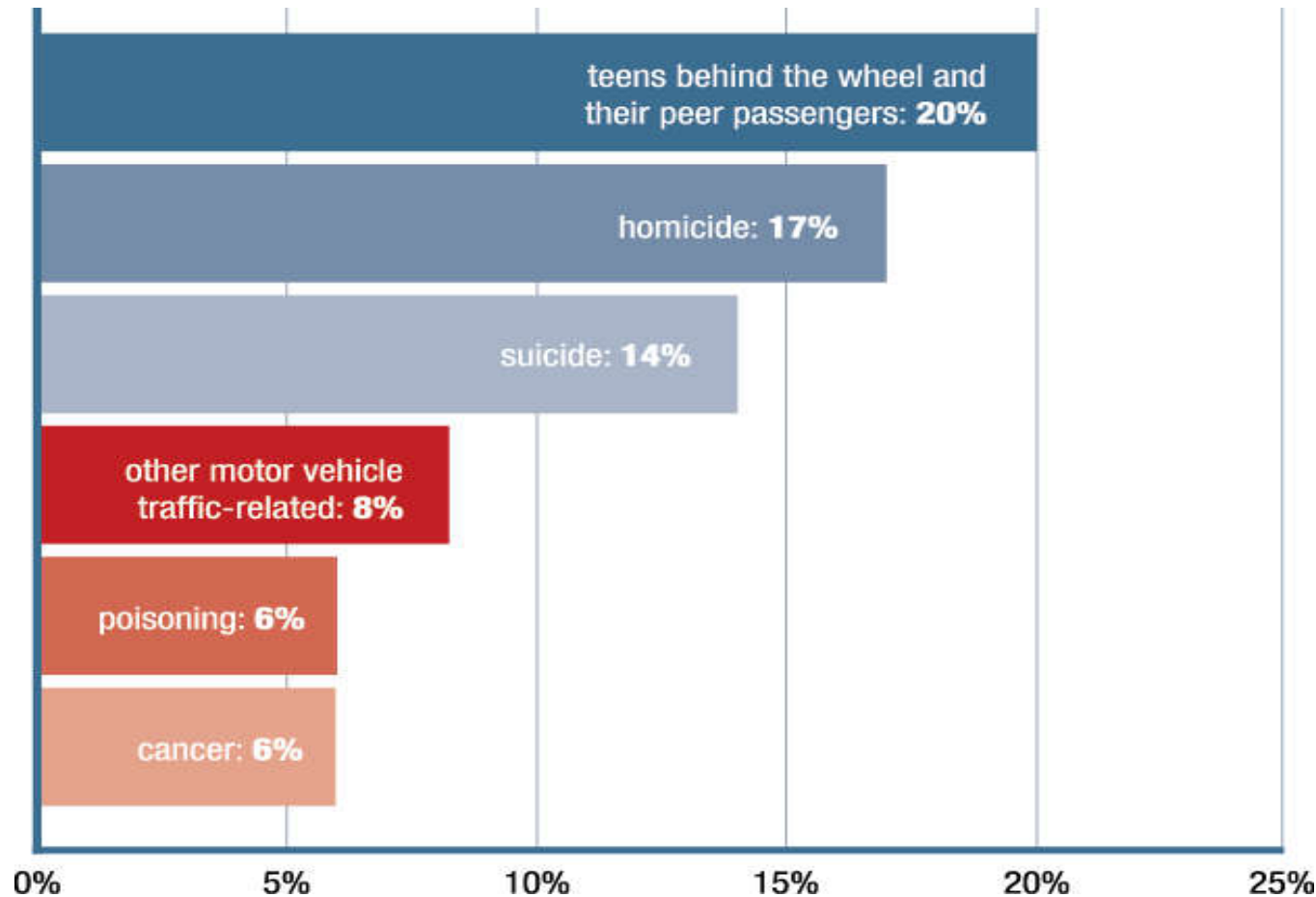
Individual with  
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factors

**INDICATED**

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# Motor Vehicle Crashes – Leading Cause of Death for Teens



Source: Miles to Go , CHOP, 2012.





## UNIVERSAL PREVENTION: Our science is starting to discover what typical teen driver needs

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# Universal: Ensure quantity & variety of practice



## Teen Driving Plan: CHOP-Developed Intervention

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### TeenDrivingPlan Parent Guide

**Driving Environments**

Creating the Right Learning Environment

**Additional Resources**

Use the Goal Guide tip sheet to remind your teen of goals for each drive.

**GOALS**

The Logging and Rating Tool helps families track their practice and record where teens need work.

**LOG**

Download and Share with parents. Help parents boost their teen's driving practice.

MY PLANS MY LOGS TUTORIALS PARENT CORNER

WELCOME BACK, JOE.

**SUMMARY**

TIME PRACTICED **5:23**

**PRACTICE BY ENVIRONMENT**

Parking Lot	1:51
Residential	1:37
Intermediate Roads	0:58
Commercial Roads	0:12
Highways	0:15
Country Roads	0:30

**MESSAGES**

**QUICK TIPS**

**COMMON ERRORS**

ENVIRONMENT: RESIDENTIAL  
GOAL: HAZARD DETECTION

- Failing to recognize potential hazard
- Not being prepared to react appropriately to hazards
- Not knowing the appropriate reaction to an anticipated danger

Have you practiced since your last visit?

YES

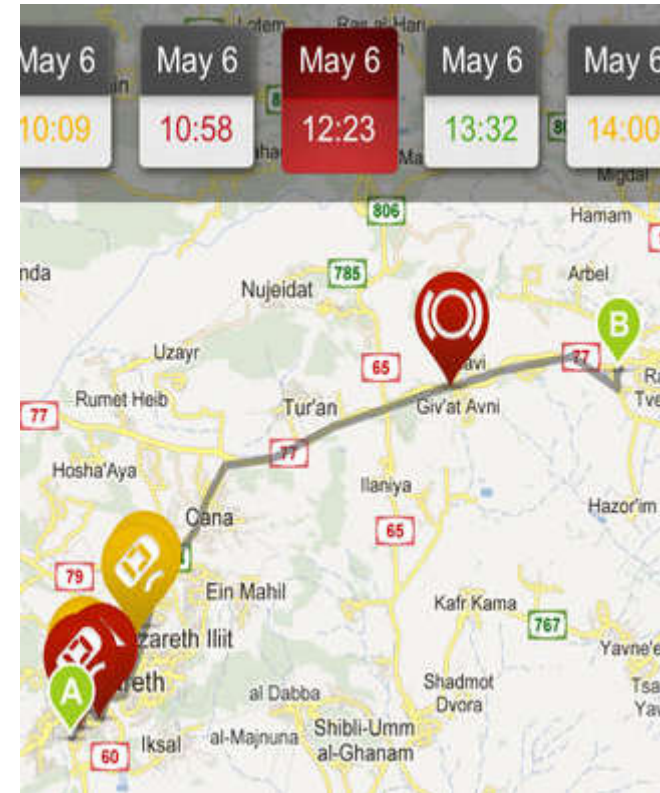
NO

VIEW TIP SHEETS

[https://www.teendriversource.org/tools/for\\_parents/detail/244](https://www.teendriversource.org/tools/for_parents/detail/244)



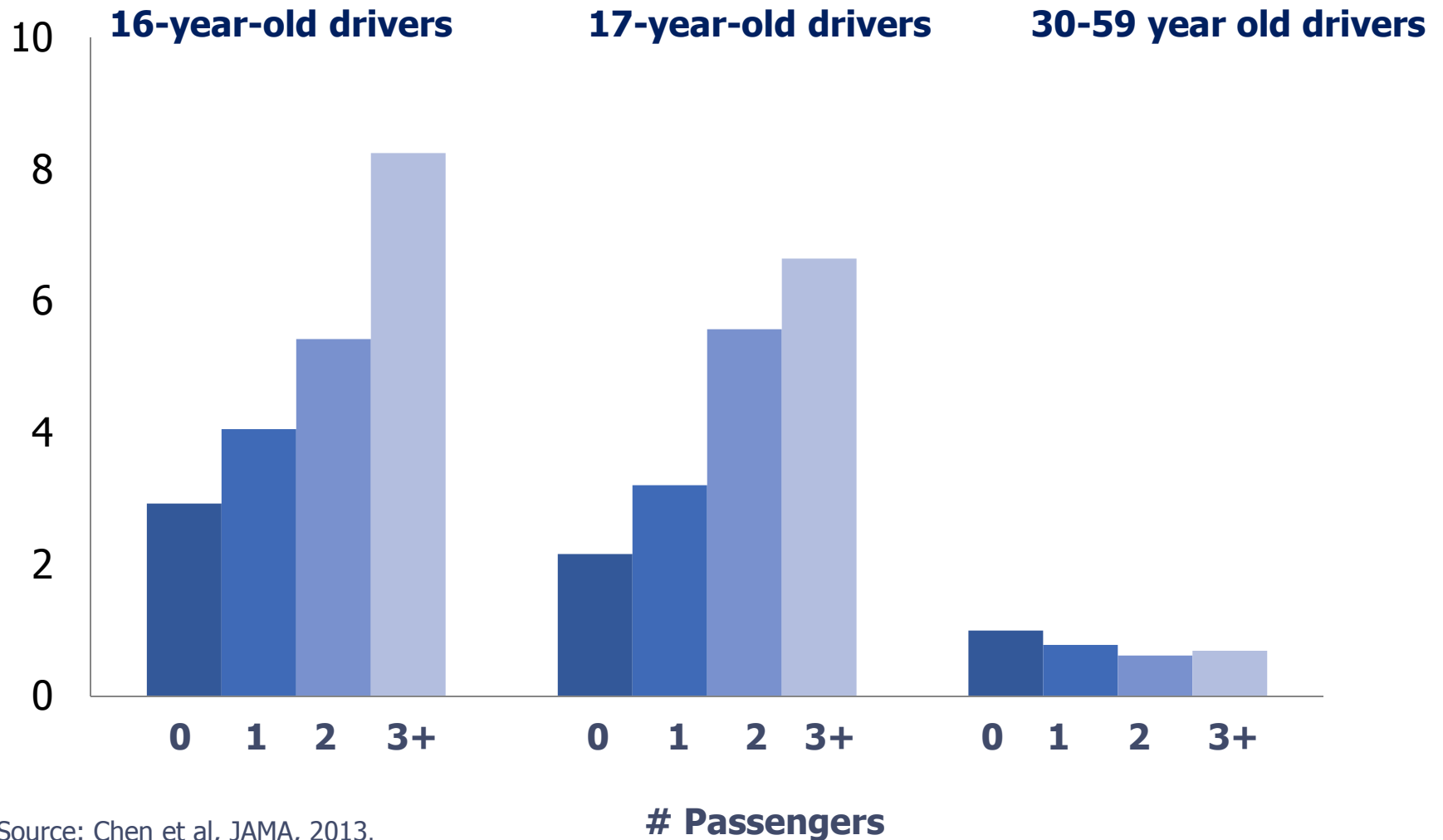
# Universal: Decals/parents/monitoring





# Universal: GDL limits on passengers

## Crashes per 10,000 Trips, by # of Passengers



Source: Chen et al, JAMA, 2013.



# SELECTED PREVENTION:

Our science - lacking for non-typical teens  
Urgent need for interventions



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# Selected Prevention – Novice Drivers

Move from protection of the typical to include the protection of “edge cases”

- People’s characteristics and states intersect with the limits of automotive technology

Safe transition from manned to autonomous driving to advance accessible mobility for all people, including those with disabilities

- Autonomous driving features open up opportunities for mobility for those that traditionally didn’t have it – how do we protect them – human factors/accessibility/passive safety
- The vehicle will expect the driver to respond as a typical driver would

Likely requires broadening of traditional engineering to user-centered, participatory design and human factors research that optimizes technology





## INDICATED PREVENTION: Our science is lacking: What do we do after unsafe behavior/ crash?

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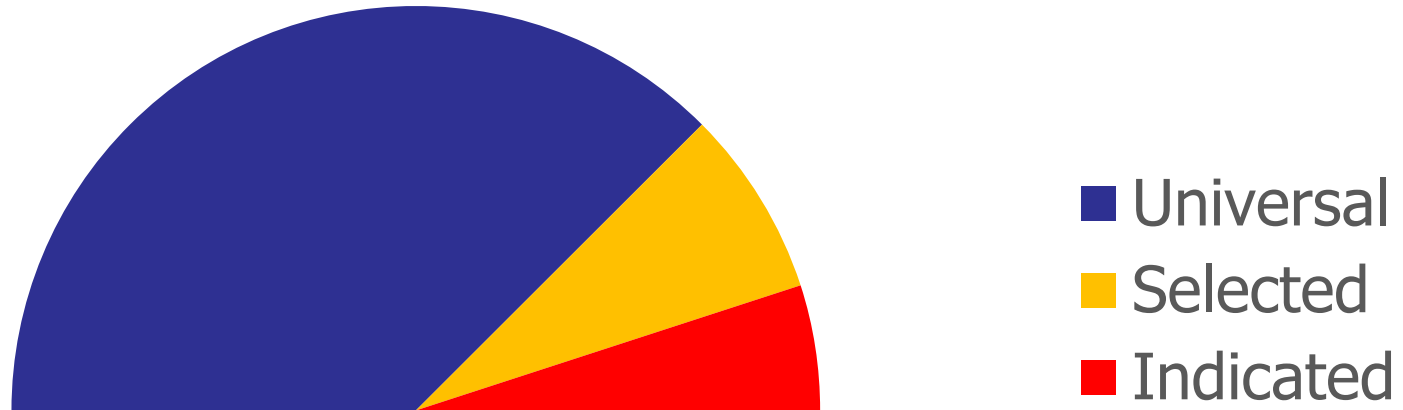
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