CChIPS | Center for Child Injury Prevention Studies

THE SUPPORT LEG OF THE REAR FACING CHILD RESTRAINT

Kristy Arbogast
Declan Patton, Jalaj Maheshwari, Aditya Belwadi

Children's Hospital of Philadelphia
RESEARCH INSTITUTE

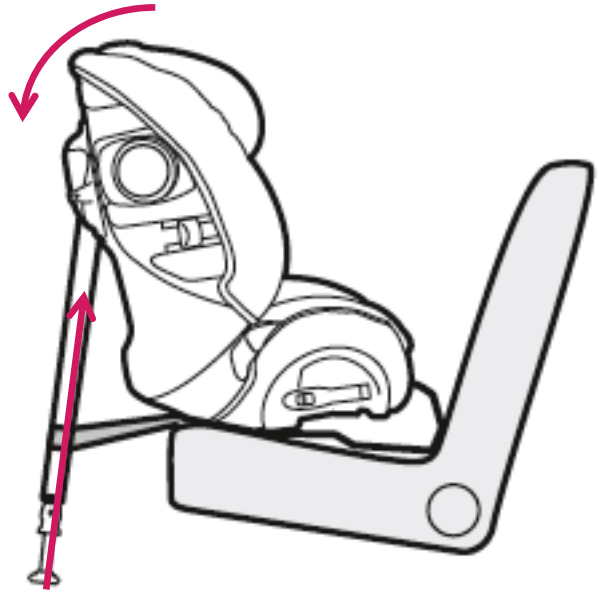
THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

BACKGROUND

- Correctly used CRS are associated with a substantial reduction of injury and mortality risks in motor vehicle crashes (Elliot et al. 2006)
- Epidemiologic and biomechanical data suggests that toddlers are provided greater protection when restrained in a rearward-facing CRS (McMurray et al. 2018)
- Features exist in rearward-facing CRS to encourage their use

BACKGROUND

- Some European rearward-facing CRS models are designed with a support (load) leg to reduce rotation during frontal impacts
- CRS models with this feature are entering US market
  - Infant and convertible
- US FMVSS 213
  - No regulation on support legs



BACKGROUND

- In 2011, Volvo petitioned to include a floor in the FMVSS 213 test bench
  - More reflective of real-world conditions
  - Allow a support leg to be used during tests
  - Facilitate rearward-facing child seating for as long as practicable
- In 2020, NHTSA released an NPRM for FMVSS 213 test bench improvements and denied petition
  - Consumers may not properly use a support leg
  - Concerned about underfloor storage compartments

BACKGROUND

- Few previous studies examining performance of support legs
- Sherwood et al. (2004)
  - Sled tests using the CRABI-12
  - RF CRS model with support leg had the lowest HIC_{15}
- Sherwood et al. (2007)
  - Sled tests using CRABI-12 and Q1.5
  - HIC_{15} values for RF Euro CRS models were lower than for RF US CRS models
  - Attributed to the presence of support legs

OBJECTIVES

Phase 1: To evaluate the presence of a support leg in rearward-facing infant CRS models during frontal impacts

Patton et al. (2020) Stapp Car Crash J

Phase 2: To evaluate the presence of a support leg in rearward-facing infant CRS models during frontal-oblique impacts (30°)

Patton et al. (2021) Int J Environ Res Public Health

Phase 3: To evaluate the presence of a support leg in a rearward-facing extended-use CRS model during frontal impacts

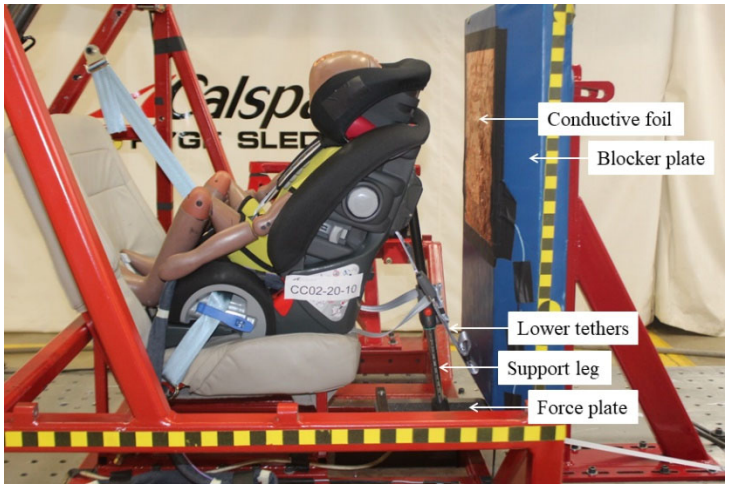
Patton et al. (2020) Stapp Car Crash J

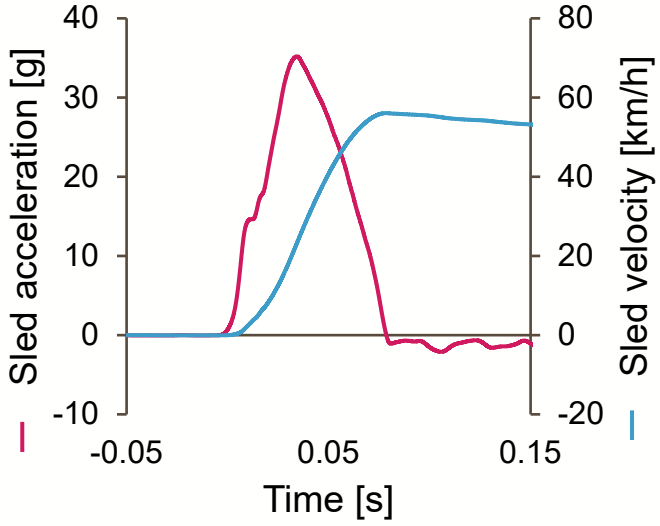
Phase 4: To evaluate the presence of a support leg in rearward-facing infant CRS models for various positions (i.e. braced, touching, gap) during frontal impacts

Patton et al. (2022) Traffic Inj Prev

METHODS – TEST SETUP

- Consumer Reports test buck
  - Test bench based on 2010/11 Ford Flex SUV 2nd row outboard seat
  - Springs, foam and seat cushions were replaced every six tests
  - Force plate installed on floor to measure GRF of leg
  - 5x high-speed cameras
  - Blocker plate
    - Representative stiffness/ geometry of front seatbacks
    - Angle represents the movement of the front seat during crash
    - Conductive foil to quantify ATD head contact with blocker plate
- Consumer Reports frontal pulse





METHODS – ATD & CRS

- CRABI-12 and Q1.5
- Two RF infant CRS models
  - Flexible anchors (FAICRS)
  - Rigid anchors (RAICRS)
- Tested with and without support leg

PHASE 1 PHASE 2 PHASE 3 PHASE 4

RESULTS

Q1.5 in FAICRS

Q1.5 in RAICRS

With support leg Without support leg

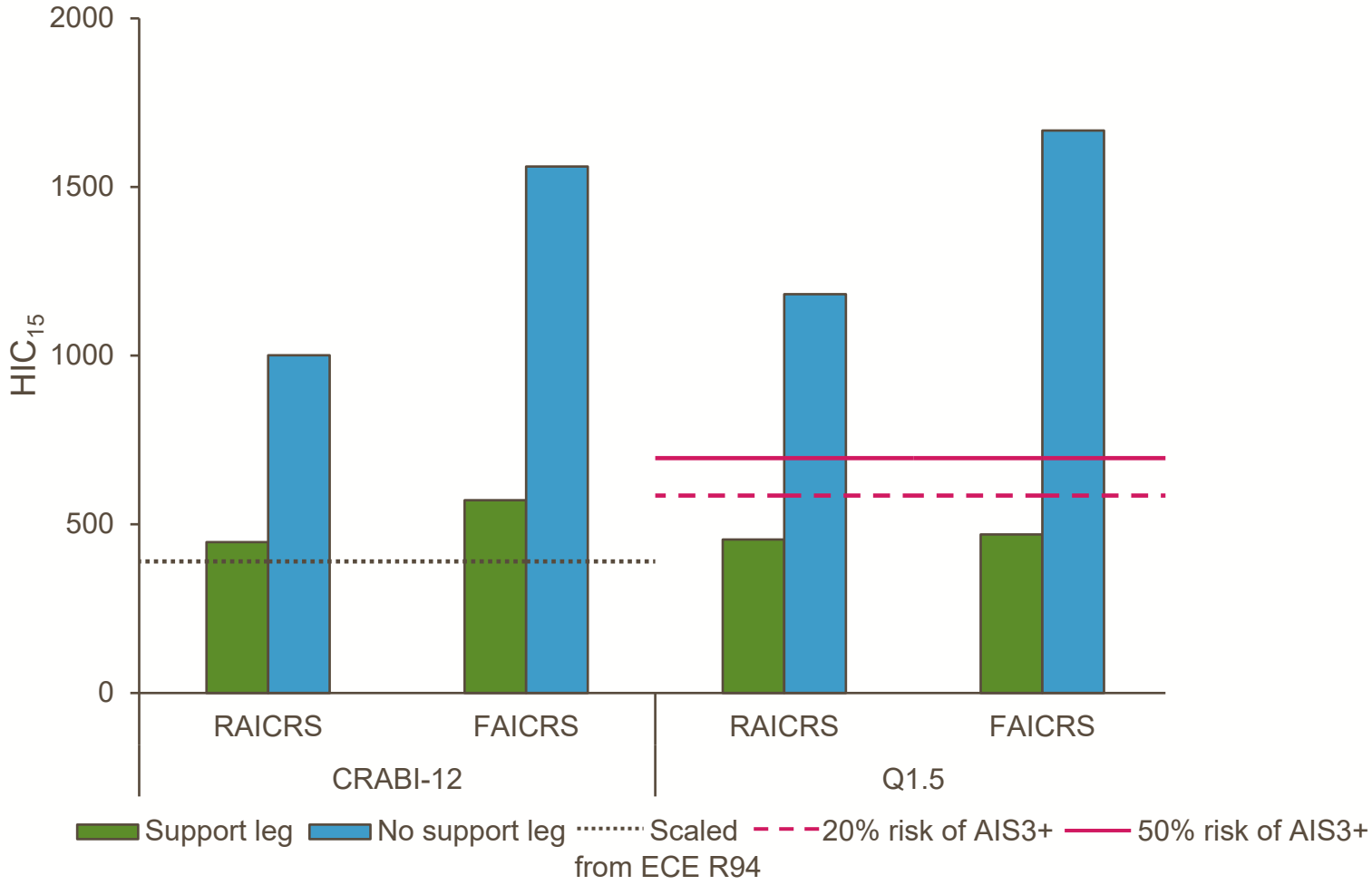
Children's Hospital of Philadelphia RESEARCH INSTITUTE

The Ohio State University WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

PHASE 1 PHASE 2 PHASE 3 PHASE 4

RESULTS



Children's Hospital of Philadelphia RESEARCH INSTITUTE

The Ohio State University WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

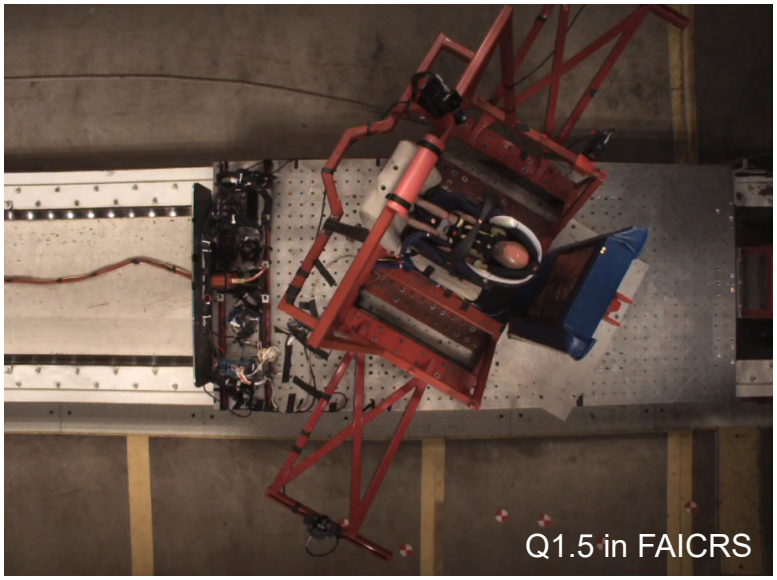
MOTIVATION

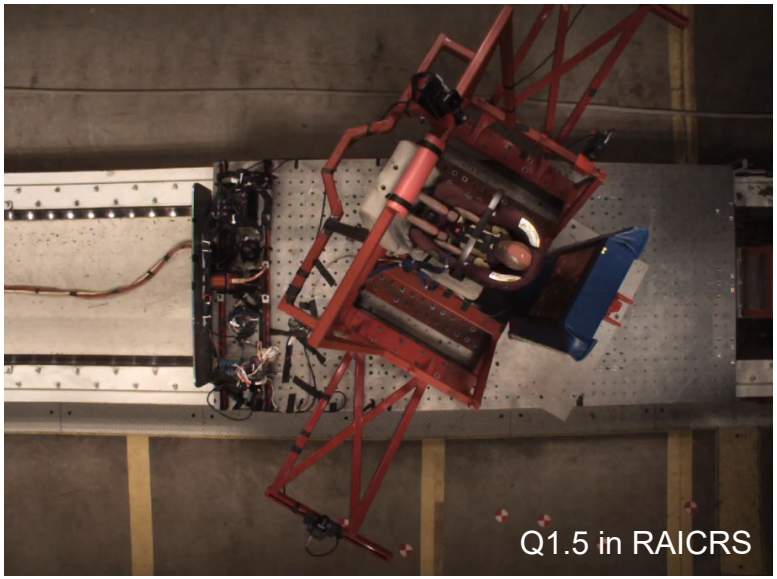
- Oblique principal directions of force are common in real-world crashes and are of specific research interest (Maltese et al. 2007)
- No previous study had assessed RF CRS with support legs in frontal-oblique impacts

PHASE 1 **PHASE 2** PHASE 3 PHASE 4

METHODS

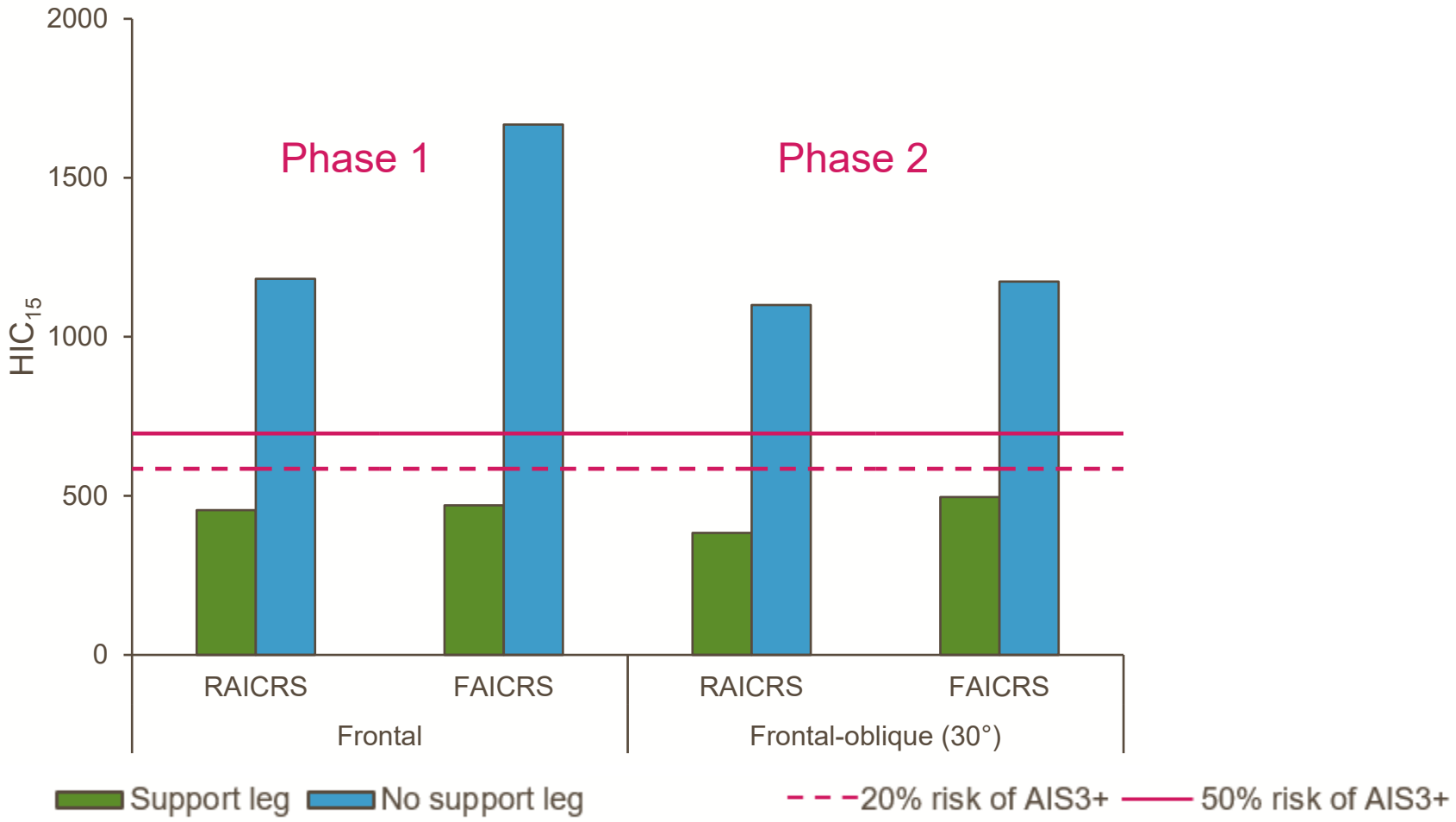
- Consumer Reports
  - Test buck rotated 30°
  - Frontal pulse
- Q1.5
- Two RF infant CRS models
  - Flexible anchors (FAICRS)
  - Rigid anchors (RAICRS)
- Tested with and without support leg


Q1.5 in FAICRS


Q1.5 in RAICRS

PHASE 1 PHASE 2 PHASE 3 PHASE 4

RESULTS



Children's Hospital of Philadelphia RESEARCH INSTITUTE

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

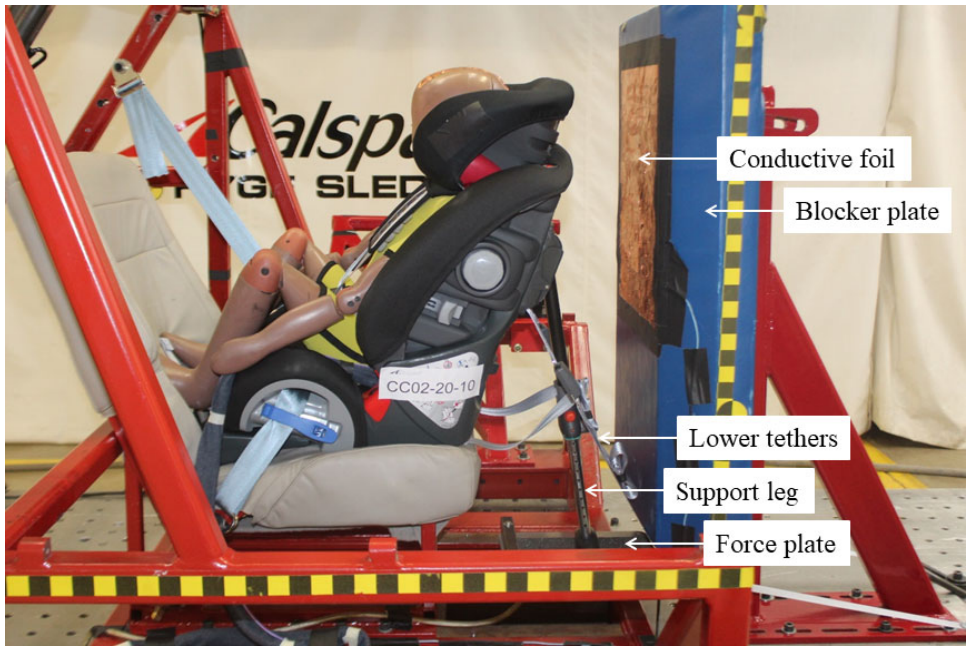
MOTIVATION

- Some European CRS are “extended-use” that can accommodate occupants RF up to 6 years
- Extended-use CRS is not a new concept…

For children between one and seven years of age the best way to solve the problem seems to be a well padded seat properly anchored on the rear side of the front seat backrest (Aldman 1963)

METHODS

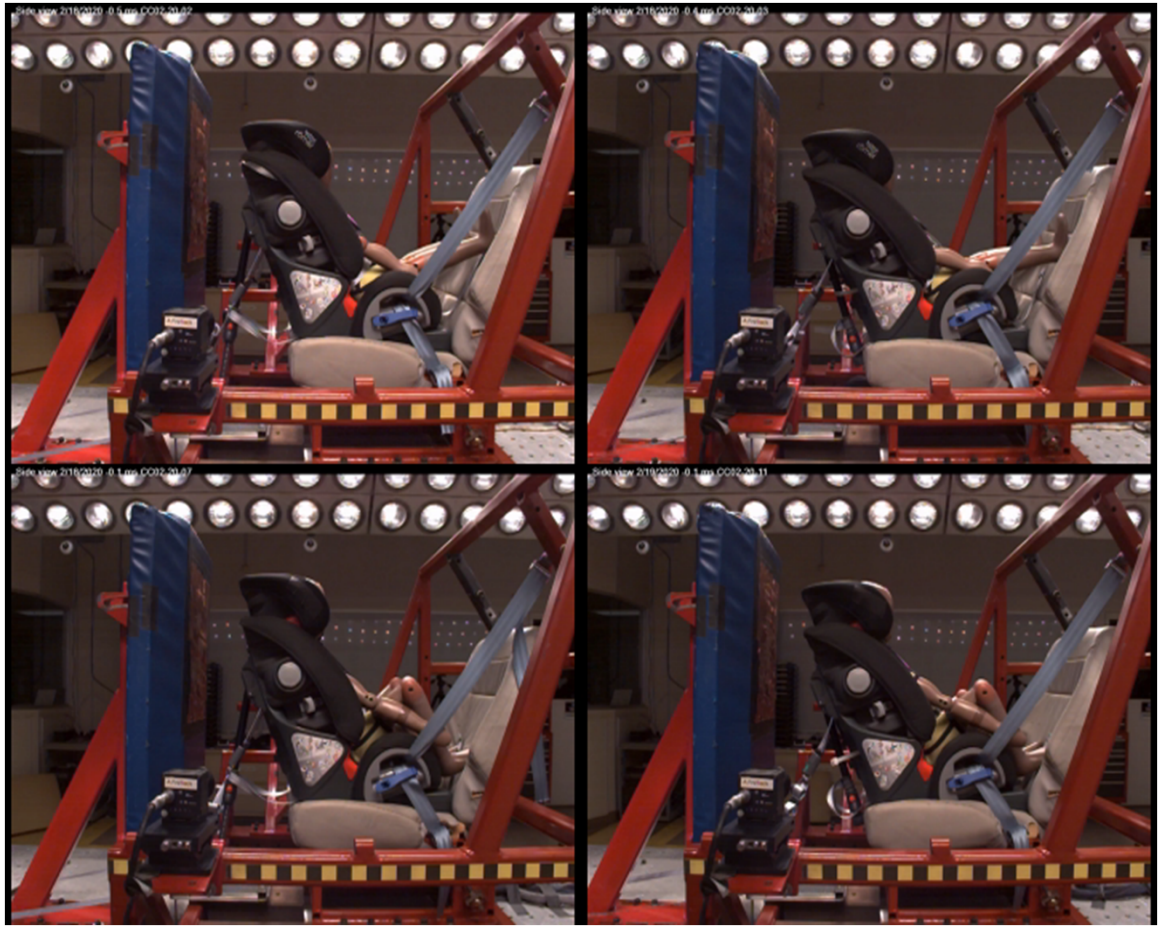
- Consumer Reports
  - Test buck
  - Frontal pulse
- Q3 & Q6
- RF extended-use CRS model
  - European model
  - Seat belt attachment
- Tested with and without support leg



RESULTS

Q3 in convertible CRS

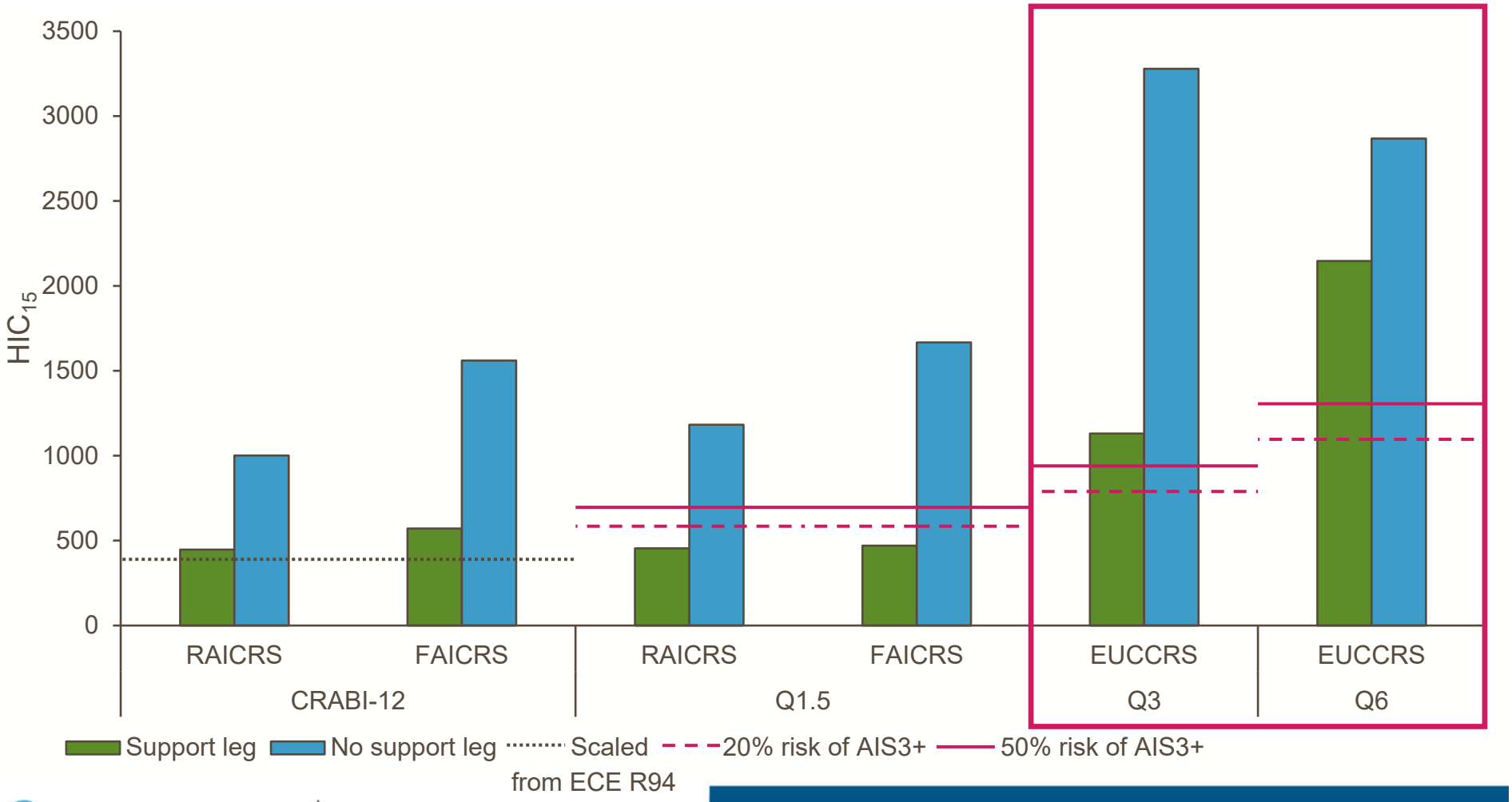
Q6 in convertible CRS



With support leg Without support leg

PHASE 1 PHASE 2 PHASE 3 PHASE 4

RESULTS



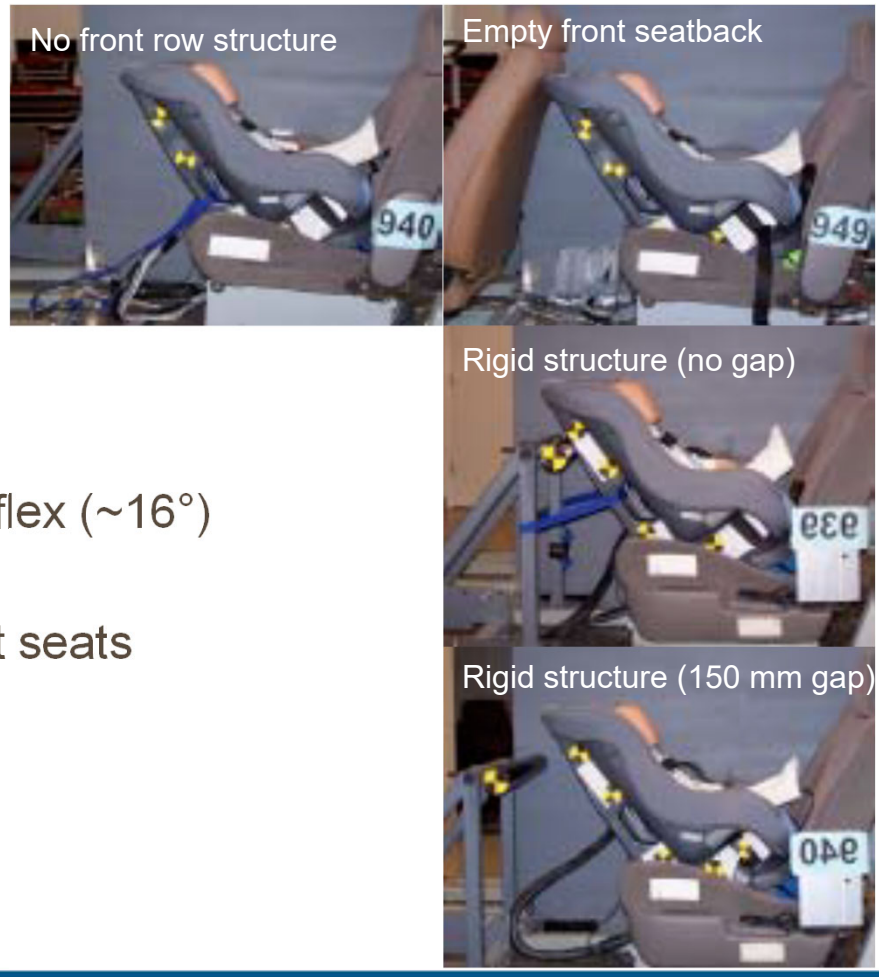
Children's Hospital of Philadelphia RESEARCH INSTITUTE

The Ohio State University WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

MOTIVATION

- Sherwood et al. (2005)
  - FMVSS 213 frontal impact
  - CRABI-12 ATD
  - 3x RF CRS models
    - No front row structure
    - Empty front row vehicle seat
      - No contact due to seatback flex (~16°)
      - Ford Mustang 1994-1997
      - Not representative of current seats
    - Rigid structure with no gap
      - Lowest head injury metrics
    - Rigid structure 150 mm gap
      - Highest head injury metrics



METHODS

- Consumer Reports test buck
- FMVSS 213 frontal impact pulse
- Blocker plate replaced with front row seatback
  - Contemporary model GM pickup truck
  - Manual track and recline adjustment
  - ~25° recline
- Q1.5 in RF infant CRS
- Q3 in RF convertible CRS
- Tested with and without support leg

PHASE 1 PHASE 2 PHASE 3 **PHASE 4**

METHODS – Q1.5 INFANT CRS

With support leg

Without support leg

Braced
-20 mm

Touching
0 mm

Gap
+50 mm

Children's Hospital of Philadelphia RESEARCH INSTITUTE | The Ohio State University WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

PHASE 1 PHASE 2 PHASE 3 **PHASE 4**

METHODS – Q3 CONVERTIBLE CRS

With support leg

Without support leg

Braced
-20 mm

Touching
0 mm

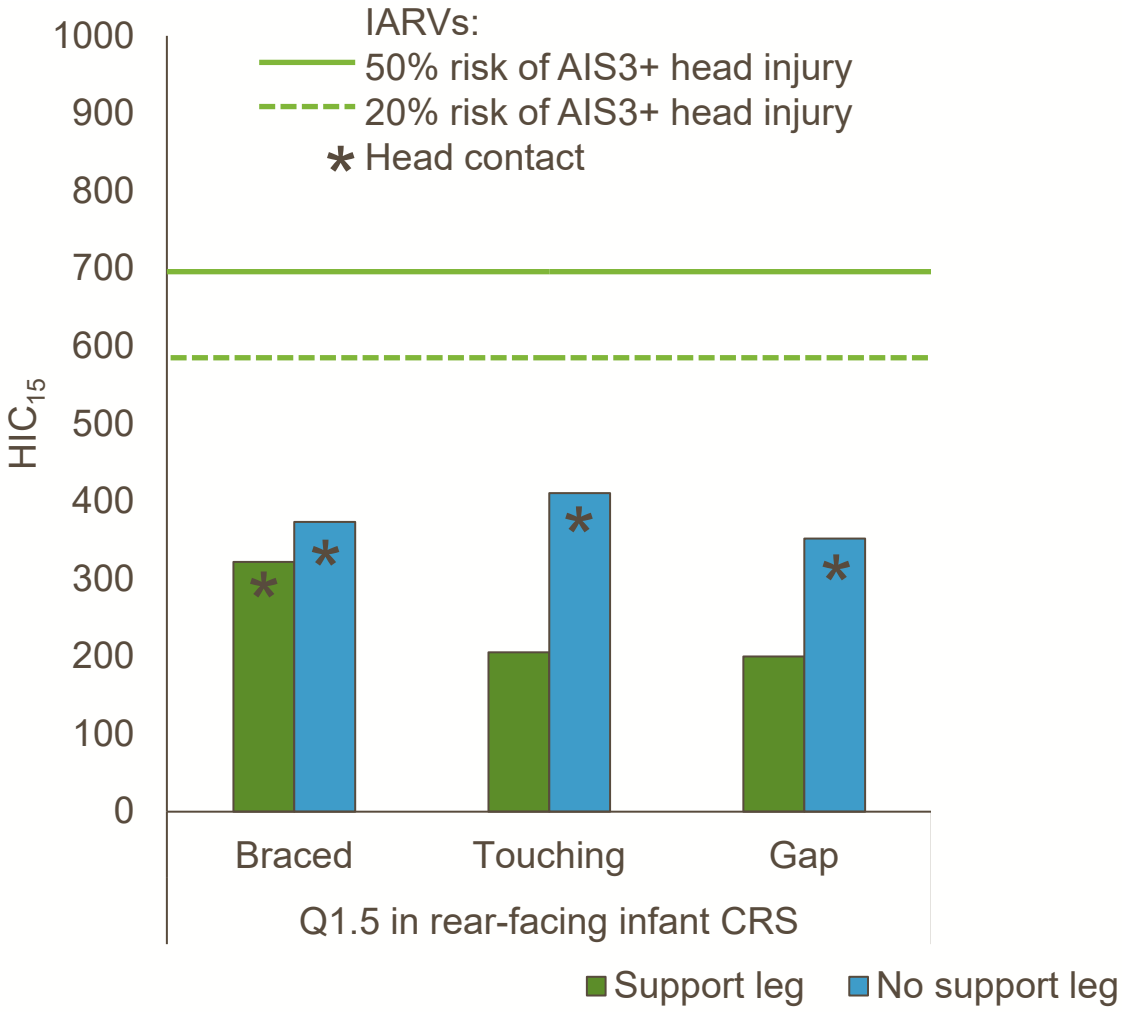
Gap
+50 mm

Children's Hospital of Philadelphia RESEARCH INSTITUTE | The Ohio State University WEXNER MEDICAL CENTER

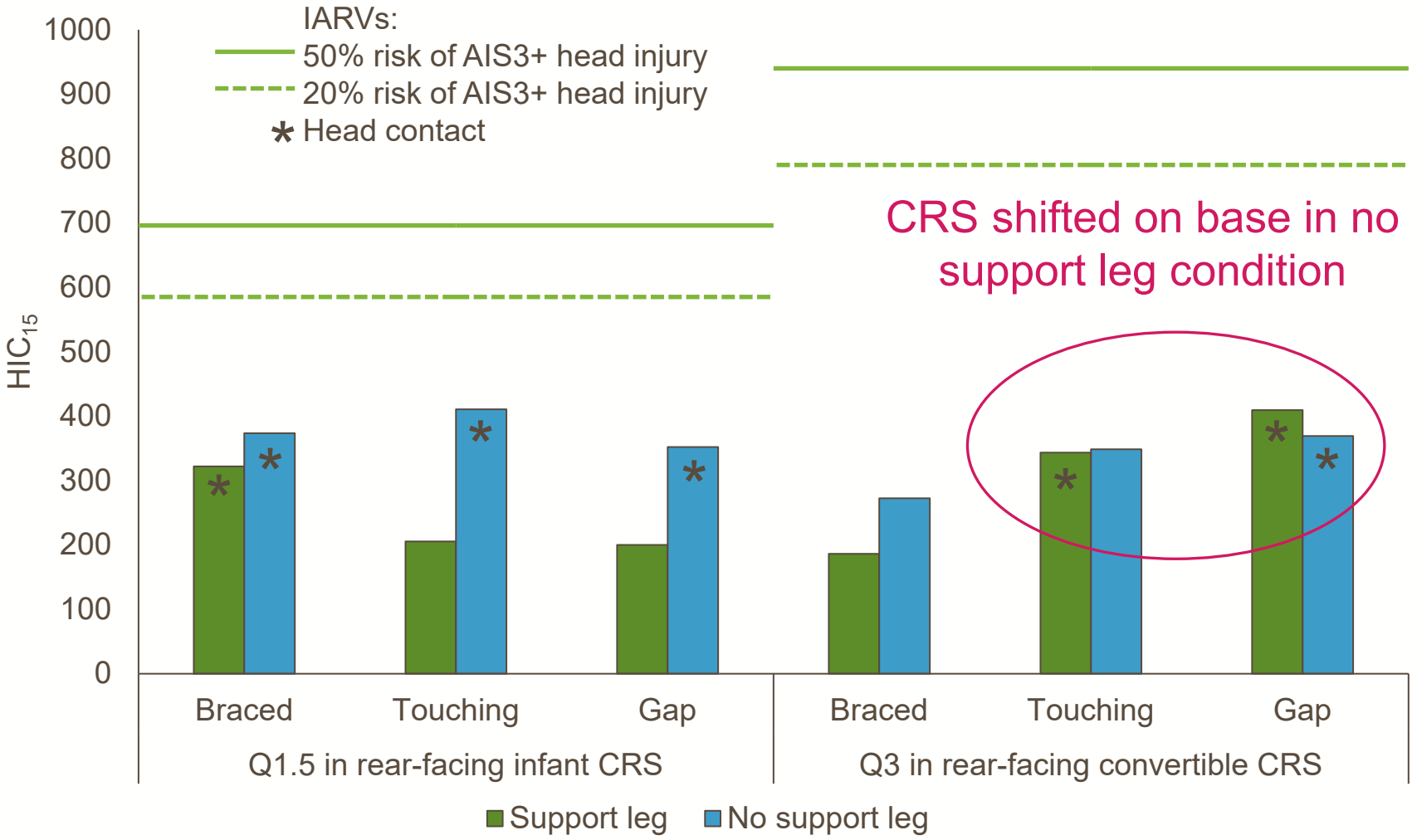
CChIPS | Center for Child Injury Prevention Studies

	Braced -20 mm	Gap +50 mm
With support leg		
Without support leg		

RESULTS – HEAD

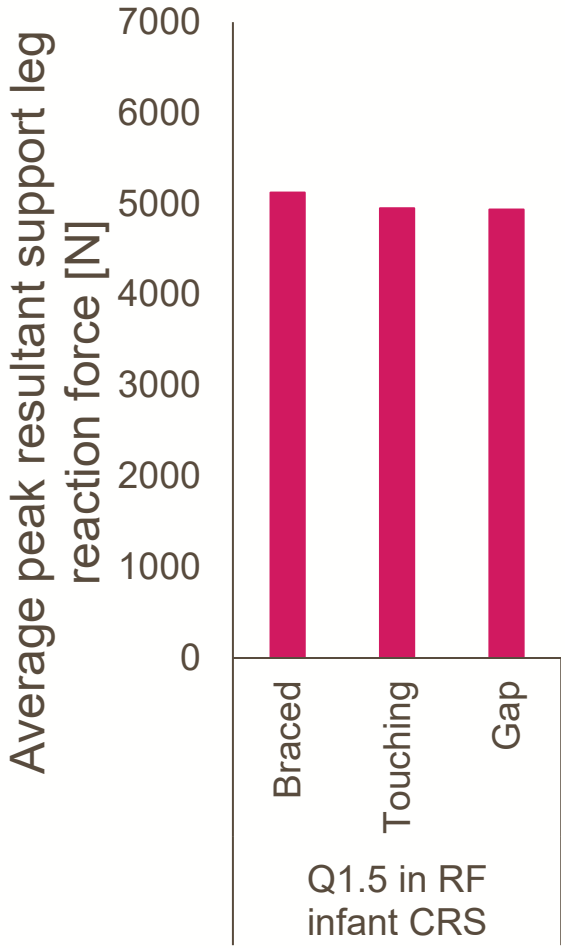


RESULTS – HEAD

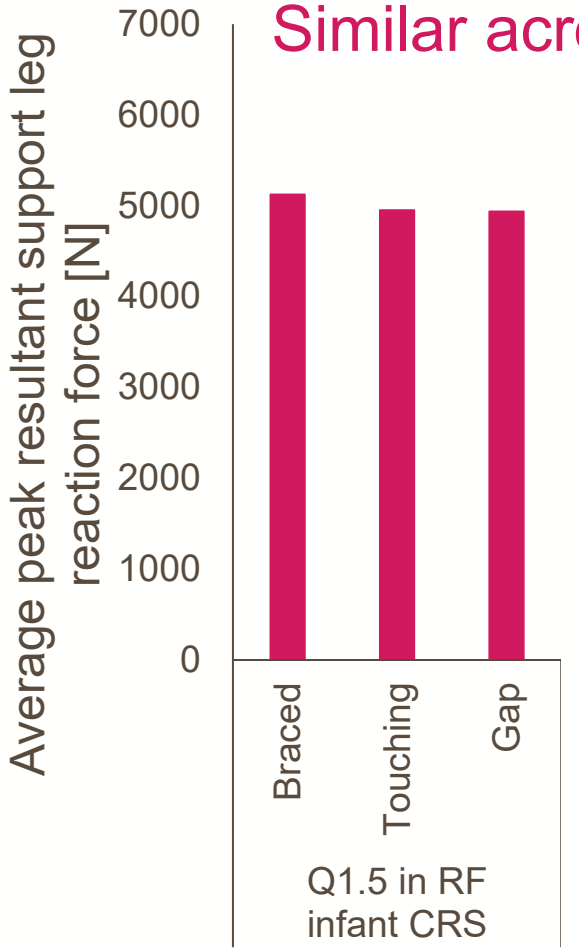


	Braced -20 mm	Gap +50 mm
With support leg		
Without support leg		

RESULTS - SUPPORT LEG



RESULTS - SUPPORT LEG

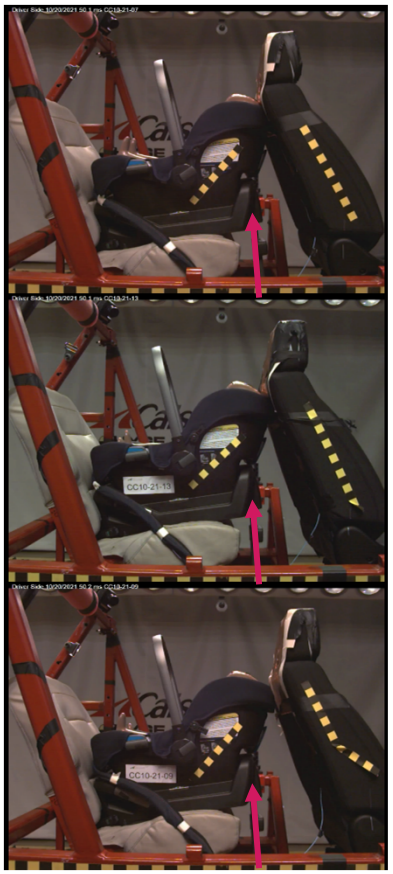


Q1.5 in RF infant CRS

Braced

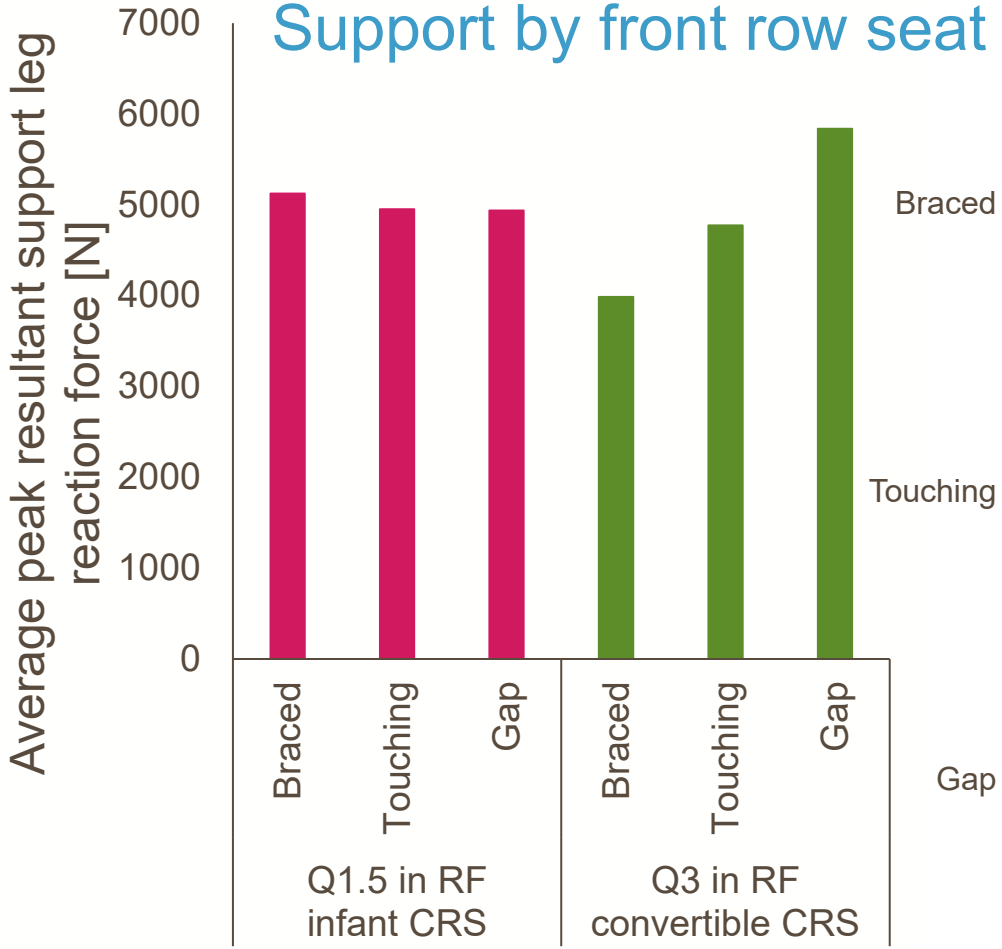
Touching

Gap



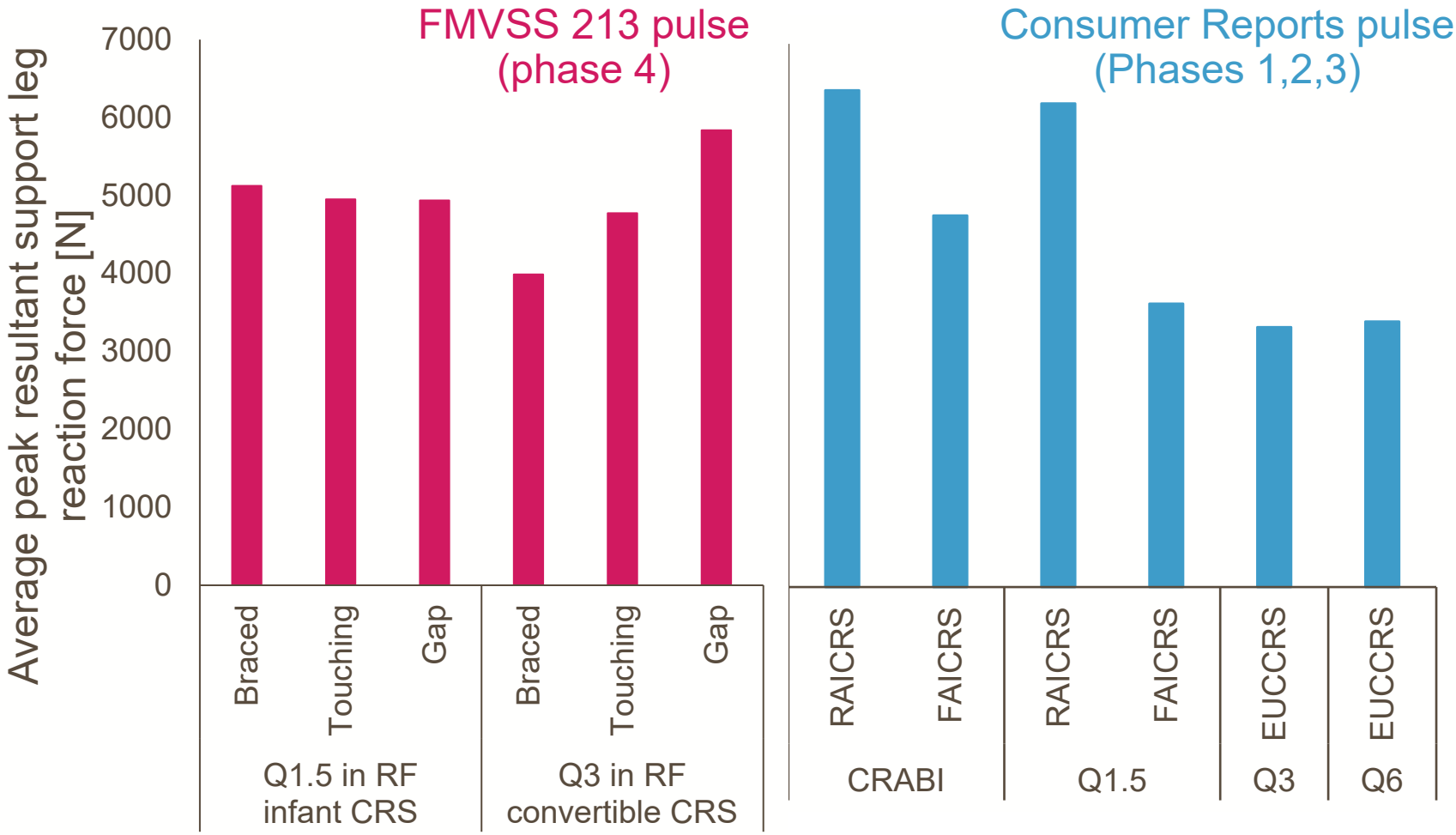
RESULTS - SUPPORT LEG

RESULTS - SUPPORT LEG



PHASE 1 PHASE 2 PHASE 3 PHASE 4

RESULTS - SUPPORT LEG



SUMMARY

Phase 1: presence of support leg for RF infant CRS reduced HIC15 in frontal impacts

Phase 2: presence of support leg for RF infant CRS reduced HIC15 in frontal-oblique impacts (30°)

Phase 3: presence of support leg for RF extended-use CRS reduced HIC15 in frontal impacts

Phase 4: presence of support leg for RF infant CRS reduced HIC15 in frontal impacts, but less clear for convertible CRS due to CRS shifting on base for no support leg (misuse) condition

IAB MEMBER COMPANIES 2022/23

Children's Hospital of Philadelphia
RESEARCH INSTITUTE

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER

CChIPS | Center for Child Injury Prevention Studies

CChIPS | Center for Child Injury Prevention Studies

THE SUPPORT LEG OF THE REAR FACING CHILD RESTRAINT

Kristy Arbogast
Declan Patton, Jalaj Maheshwari, Aditya Belwadi

Children's Hospital of Philadelphia
RESEARCH INSTITUTE

THE OHIO STATE UNIVERSITY
WEXNER MEDICAL CENTER