



SAFE AND SOUND

PAVING THE WAY

2018
Annual Report

CChIPS | Center for Child Injury Prevention Studies

PARTNERING FOR SAFETY

Welcome to the CChIPS 2017-2018 Project Year!

The Center for Child Injury Prevention Studies (CChIPS) takes a unique approach to child safety research. For over a decade, CChIPS has been a hub of innovation and collaboration for industry members and academic researchers committed to improving the safety of children and adolescents.

A Message from Our Directors



Kristy Arbogast, PhD, John H. Bolte IV, PhD,
and Flaura Winston, MD, PhD, co-directors, CChIPS

Founded in 2005 by the National Science Foundation (NSF), CChIPS' unique partnership includes research sites at the Children's Hospital of Philadelphia (CHOP) Research Institute and The Ohio State University (OSU), and our Industry Advisory Board (IAB) comprises 18 member organizations from industry, advocacy, and government agencies.

In 2017-2018, the IAB funded 10 research projects, bringing the Center's 13-year total to more than 140 completed projects across the Center's five-domain research agenda. This multitude of research projects has fostered the development of multiple lines of research, including data linkage; human volunteer testing; driving simulator research; child passenger safety; and naturalistic driving behavioral research.

In this Annual Report, you will find highlights of live conversations held with our principal investigators about their CChIPS projects, discussing a range of topics including project aims, results, and industry relevance. We hope that this format allows the expertise, passion, and dedication of our CHOP and OSU-based research scientists to shine through. These conversations also illuminate just how important a role our IAB members

play in the research process and the iterative process that makes CChIPS research so unique. As an added benefit, IAB members also have access to the full technical research reports that contain more detailed data and analyses.

- Industry Advisory Board Members: Page 2
- Financial Update: Pages 3-4
- 2017-2018 Project Highlights: Pages 5-15
- Supplemental Research Funding: Pages 16
- Preparing Future Industry Scientists: Page 17

The Center's research portfolio is continually evolving to address current challenges and emerging issues in child injury prevention, as guided by science and our IAB member companies. In this report you will learn about projects that explore child passenger and teen driver safety in autonomous vehicles, utilize the latest technology research tools, such as the PIPER human body model, and address the distracted driving behaviors of parents and the impact on child passengers. We are proud to be a driving force behind innovative research that continues to push the envelope in working to improve child safety.

Additionally, CChIPS – through its parent center at CHOP, the Center for Injury Research and Prevention – utilizes a team of outreach and communication experts who focus on translating CChIPS research findings into appropriate messages and materials designed to reach target audiences. This includes digital communication strategies to share information, such as the cchips.research.chop.edu website, which saw a 55 percent increase in visits for calendar year 2017.

We look forward to sharing many more achievements with you in the future.

IAB MEMBER COMPANIES



◆ Founding IAB Member Company

★ Presenting Sponsor

★ 2018 ACIP Conference Sponsor – Gold

★ 2018 ACIP Conference Sponsor – Silver

CChIPS Mission Statement

The CChIPS mission is to advance the safety of children, youth, and young adults by facilitating scientific inquiry into childhood and young adult injuries and to translate these findings into commercial applications and educational programs for preventing future injuries.

For current IAB membership, please visit cchips.research.chop.edu.

FUNDING THE RESEARCH

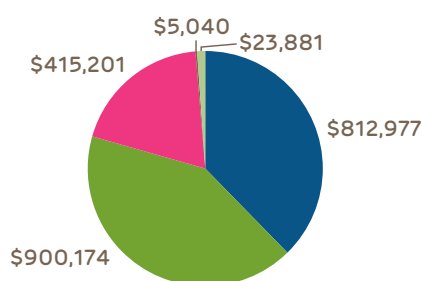
CChIPS is made possible through a grant from the National Science Foundation (NSF), as well as sponsorships from its Industry Advisory Board (IAB) members comprised of leaders in industry, small business, nonprofits, and government agencies that engage in and value scientific research and development to improve child safety. In 2017, each full voting IAB member contributed \$57,500* to support the CChIPS mission. Nonprofit organizations and small businesses are also given the opportunity to join for a reduced annual fee. Government agencies support CChIPS as non-voting members and contribute to the science as project mentors. Membership in CChIPS has fostered industry and small business commitment to the CChIPS mission and spurred innovation. To become a member or to sponsor research with CChIPS investigators, please contact us at cchips@email.chop.edu.



** The annual membership fee for a full voting member in 2018-2019 is \$65,000.*

In keeping with the NSF guidelines, for this consortium effort the Children's Hospital of Philadelphia Research Institute and The Ohio State University waive indirect costs for CChIPS.

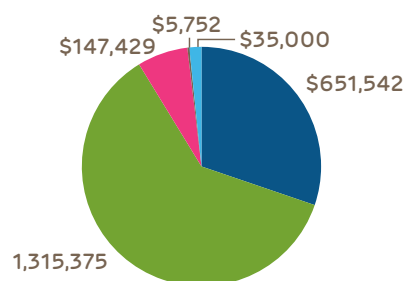
REVENUE FOR 2018



Total Revenue: \$2,157,273

- IAB Member Companies' Contributions
- Additional Member Company Contributions
- NSF Supplemental Funding
- Meeting Revenue
- NSF Center Award

EXPENDITURES FOR 2018



Total Expenditures: \$2,155,098

- Projects Awarded (IAB Funding)
- Projects Awarded (Additional Member Company Contributions and Supplemental Funding)
- Admin/Operating/Evaluator Expenses
- Meeting Expenses (ACIP & IAB Meetings)
- Marketing Expenses

HOW DO WE CALCULATE THE CCHIPS ROI?

The CChIPS Industry Advisory Board (IAB) has three different membership types tied to varying annual fees:



Large Business*
\$57,500



Government/Nonprofit
\$25,000



Small Business
\$15,000

18 Members

\$812,977 in research funds
excluding supplemental funds

The research pool funded 11 projects in 2017-2018, which fall within five interest areas. Projects are often categorized in more than one area.



Child Restraint
Design and
Performance

5 Projects

\$507,195**



Consumer/Driver
Behavior

3 Projects

\$358,531**



Crash Avoidance
& Autonomous
Vehicles

3 Projects

\$358,531**



Vehicle Restraint
Performance

5 Projects

\$448,746**



Dummy
Biofidelity

4 Projects

\$429,183**



What Does the CChIPS ROI Look Like for One Member?

In 2017-2018, a large business  with an interest in child restraint design and performance  contributed \$57,500 for access to research valued at \$507,195.

* The annual membership fee for a full voting member in 2018-2019 is \$65,000.

** These values include the cost of individual projects coupled with the institutional indirect rates from academic partners to more accurately represent the actual cost of conducting research.

RESEARCH IN ACTION:

2017-2018 Project Highlights

To make the CChIPS research portfolio more accessible to a broad audience with a range of professional backgrounds and expertise, we asked our principal investigators to tell us about their projects. We hope you enjoy the highlights from these conversations. Full abstracts for each project are available on the [CChIPS website](#). Detailed technical reports are made available to IAB member companies, and findings from the majority of projects are published in the peer-reviewed literature.

PROJECT INTEREST AREAS

The CChIPS research portfolio can be categorized by five interest areas below. Look for these icons next to each project summary.



Dummy Biofidelity



Vehicle Restraint Performance



Child Restraint Design and Performance



Consumer/Driver Behavior



Crash Avoidance & Autonomous Vehicles

GLOSSARY OF COMMONLY USED TERMS

ATD – anthropomorphic test device; also known as a crash test dummy

CRS – child restraint systems; including rear- or forward-facing car seats and belt-positioning booster seats

FMVSS 213 – Federal Motor Vehicle Safety Standard used to certify child restraints

LATCH – Lower Anchors and Tethers for Children; a standardized method of attaching child restraints to motor vehicles

NHTSA – National Highway Traffic Safety Administration; an agency of the US Department of Transportation dedicated to saving lives, preventing injuries, and reducing economic costs due to road traffic crashes



AN ANALYSIS OF THE INTERACTION BETWEEN CHILD OCCUPANTS AND DEPLOYING FRONTAL PASSENGER AIR BAGS - A MODERN EXAMINATION

Principal Investigator:

Aditya Belwadi, PhD, Children's Hospital of Philadelphia

Project Team Member:

Kristy Arbogast, PhD, Children's Hospital of Philadelphia

Students:

Jalaj Maheshwari, University of Pennsylvania;

Shreyas Sarfare, University of Pennsylvania

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Eric Dahle**, Goodbaby International; **Mark LaPlante**, Graco Children's Products Inc.;

Hiromasa Tanji, TK Holdings Inc.; **Schuyler St. Lawrence**, Toyota USA; **Julie Kleinert**, Emeritus Chair; **Uwe Meissner**, Technical Advisor

WHAT DOES THIS PROJECT STUDY?

Kids under the age of 13 are recommended to sit in the rear seat of a vehicle, but front seat occupant safety has significantly improved in recent years. In this pilot project we explored the responses and injury outcomes of a 6-year-old child seated in a high-back booster and forward-facing CRS in the front passenger seating position, with and without a passenger air bag (PAB).

HOW DID YOU CONDUCT THE SAFETY EVALUATIONS?

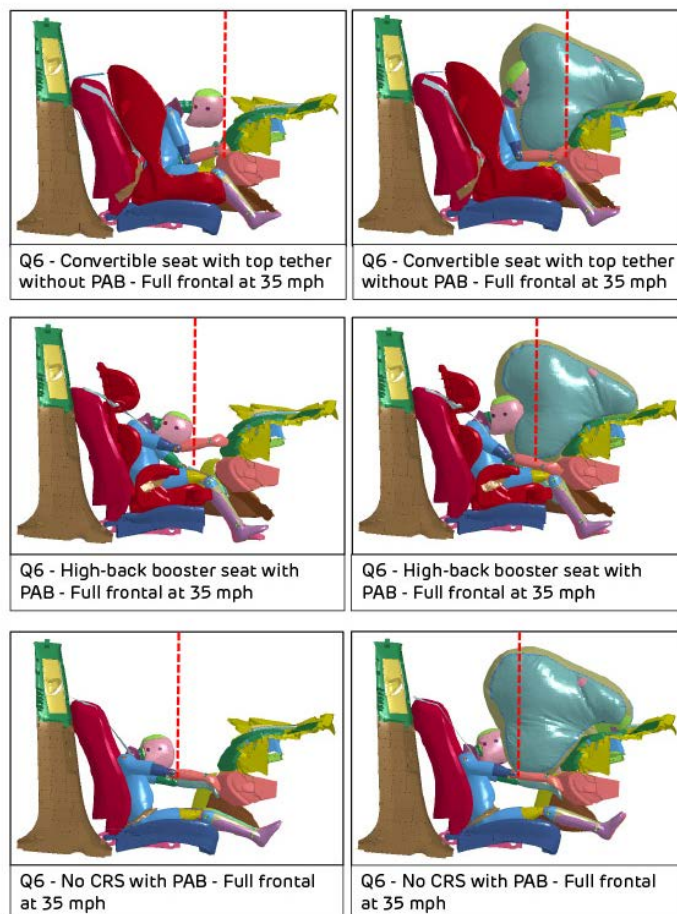
We used computational modeling to create full-vehicle and CRS models and used a combination of Q6 ATDs and human body models to simulate the occupant. This is one of the first projects in which we used a pediatric human body model called the PIPER model, which was developed specifically for injury prediction in crash tests.

WHAT WERE YOUR FINDINGS?

The way in which restraint systems and restraint design have changed was really interesting. We tested a forward-facing convertible CRS and a high-back booster and found that in both these conditions having a modern passenger air bag is more beneficial to the child than not having one in frontal impacts and frontal off-set impacts. However, these findings were very specific to the vehicle make, model, and crash conditions.

WHAT'S NEXT?

The next step is to actually do physical testing with ATDs and air bags and to also extend this to other age groups. I would love to explore what happens if a properly restrained 3-year-old, 4-year-old or 10-year-old is sitting in the front seat. I would also like to investigate several other crash modes.



Simulations of the Q6 ATD seated in the front passenger seat without a PAB (left column) and with a PAB (right column); convertible, high-back booster and no CRS conditions are depicted.



EVALUATING THE EFFICACY OF BELT POSITIONING BOOSTER SEAT DESIGN (HIGH-BACK, LOW-BACK AND HEIGHTLESS BOOSTER) IN NEARSIDE IMPACTS WITH AND WITHOUT SIDE CURTAIN AIR BAGS

Principal Investigator:

Aditya Belwadi, PhD, Children's Hospital of Philadelphia

Students:

Nhat Duong, Drexel University;

Jalaj Maheshwari, University of Pennsylvania;

Shreyas Sarfare, University of Pennsylvania

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Emily Thomas**, Consumer Reports; **Mark LaPlante**, Graco Children's Products Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Hiromasa Tanji**, TK Holdings Inc.; **Schuyler St. Lawrence**, Toyota USA; **Julie Kleinert**, Emeritus Chair; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Families have choices in booster seats, which differ in design and belt routing. We aimed to examine how these different designs – including more portable booster seat designs – affect restraint capabilities in a crash.

In Year 1 of the project, we used an instrumented Q6 ATD to test various booster seat designs in a variety of laboratory test conditions. We observed important differences in the kinematic performance of these seats. This year, we focused on how test setup affected the results. We used computational models to look at how the results changed with two test changes that better reflect the real world: (1) vehicle seat versus test bench (including adding retractors/pretensioners to the belt) and (2) presence of a side curtain air bag.

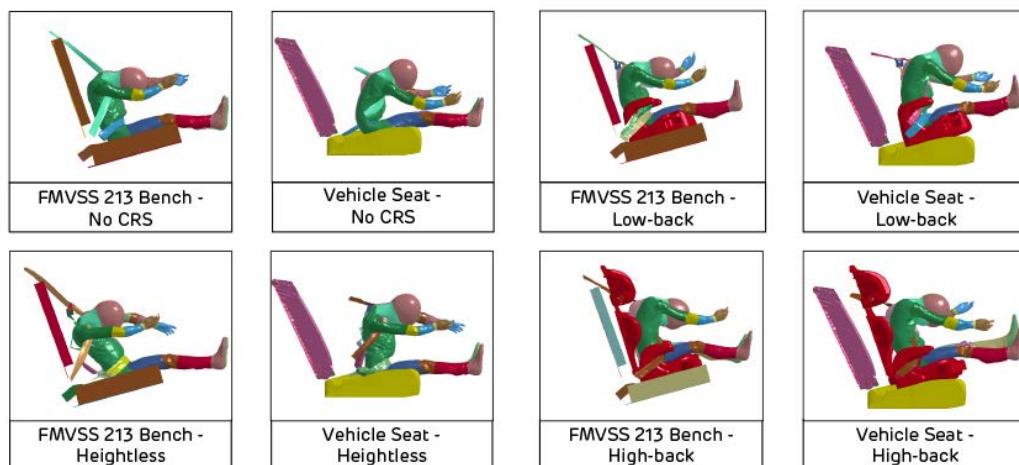
WHAT DID YOU FIND OUT IN YEAR 2?

We continued to see differences in kinematics with the different booster seat designs, but we also found that the testing platform (bench versus vehicle seat) played an

important role in the response of the occupant. For frontal tests, the addition of a retractor/pretensioner in the vehicle seat setup improved the interaction of the lap belt with the pelvis and reduced some of the unusual kinematics we observed with some newer booster seat designs in the Year 1 testing. For side impacts, the side curtain air bag showed encouraging benefits that deserve further study to quantify the nuances of the interaction of booster seats and the vehicle.

WHAT WILL YOU DO WITH THESE FINDINGS?

At the core of safety evaluation is how the specific test methodology mimics the real world. From the current study we identified the importance of testing on vehicle seats in part driven by the addition of a retractor/pretensioner. I hope these findings fuel new research in booster seat testing that better reflects real world vehicles.



Comparison of the frontal impact response of the 6YO PIPER human body model seated on the FMVSS213 bench and a vehicle seat in 4 restraint conditions (without a CRS, on a low-back booster, heightless CRS and high-back booster). All images were taken at maximum excursion.



PEDIATRIC RESPONSE TO OBLIQUE LOADING IN AIRCRAFT SEATS WITH STANDARD AND INFLATABLE SEAT BELTS

Principal Investigator:

John Bolte IV, PhD, The Ohio State University

Students:

Colleen Harkins, The Ohio State University;

Sarah Shaffer, The Ohio State University

IAB Mentors:

Amanda Taylor, Federal Aviation Administration; **Jerry Wang**, Humanetics Innovative Solutions Inc.

WHAT WAS THE PURPOSE OF THIS PROJECT?

Airplane manufacturers are now placing passenger seats at oblique angles, especially in business class and first class. We studied the performance of forward-facing and rear-facing CRS in angled airplane seats. In Year 1, led by Dr. Aditya Belwadi at CHOP, sled tests were conducted at 30 degrees. In Year 2 of this project, we looked at the level of a child's safety in an airplane seat angled 45 degrees, with and without a CRS.

HOW DID YOU CONDUCT YOUR RESEARCH?

We conducted a series of 18 tests: seven with a 3-year-old Hybrid III ATD in a forward-facing CRS, five with the 3-year-old ATD seated forward facing without any CRS, and six with the 12-month-old CRABI ATD in a rear-facing CRS. Tests were run with the ATDs seated next to a generic wall, an armrest, or nothing. The ATDs had instrumentation in their head, neck, and thorax to measure potential injuries to those body regions.

WHAT DID YOU FIND?

We found that the 3-year-old ATD sitting in a 45-degree seat without a CRS experienced head strikes that could potentially result in injury, regardless of what structure was adjacent to it (wall, arm rest, or nothing). The ATD flexed forward substantially so that in the case with no wall, it struck its head on its own knee. The tests with the 3-year-old seated in the forward-facing CRS and those with the 12-month-old in the rear-facing CRS were much more likely to result in no injuries to the children.



The 3-year-old HIII ATD seated in a forward-facing CRS positioned for the 45 degree oblique test.

WHY DID YOU CONDUCT THIS STUDY AND WHAT ARE ITS IMPLICATIONS?

The study was conducted due to the airline industry exploring the use of more angled seating positions on future aircraft designs. These angled seating positions offer benefits to the industry in more occupant space for improved comfort, but it was not known how they could affect the safety of children in the event of a crash. Ideally these results will help the FAA in its communication with families and aircraft manufacturers in improving child safety while traveling on airplanes.



INFLUENCE OF CRS FIT ON FAR-SIDE IMPACTS

Principal Investigator:

Yun Seok Kang, PhD, The Ohio State University

Co-Investigator:

Julie Mansfield, MS, The Ohio State University

Student:

Gretchen Baker, The Ohio State University

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Emily Thomas**, Consumer Reports; **Hiromasa Tanji**, TK Holdings Inc.; **Julie Kleinert**, Emeritus Chair; **Uwe Meissner**, Technical Advisor



At left, an overhead view of a rear-facing CRS shows the rotation of the CRS and the rolling of the ATD's head within the shell. At right, a front view of a forward-facing CRS shows the lateral excursion of the ATD.

WHAT WAS THE PURPOSE OF THIS PROJECT?

We studied how CRS that are not ideally fitted to the vehicle and child affect the child's safety in far-side impact scenarios. We ran sled tests to examine the performance of both forward- and rear-facing CRS with different fit conditions. We looked at far-side impacts because those produce more kinematic change than near-side impacts.

We used an ideally fitted CRS as a baseline to test slightly non-ideal fits, such as CRS installed with a pool noodle to create the proper recline angle, CRS with a narrow base, CRS with a gap behind the seat bight (the intersection between the bottom vehicle seat cushion and the back cushion) and CRS with a gap behind the back near the top of the CRS. Caregivers and/or parents may commonly experience these non-ideal installations. However, it is important to note that we did not create a scenario in which the CRS was actually misused; a non-ideal fit does not mean misuse. Proper CRS fit depends on the vehicle and CRS models.

HOW DID YOU DETERMINE WHAT NON-IDEAL INSTALLATIONS TO STUDY?

We used a matrix created in a previous CChIPS study led by Julie Mansfield. She measured CRS and vehicle seat dimensions and then determined the ideal fit and a range of less-than-ideal fits based on those measurements.

WERE YOU SURPRISED BY ANY OF YOUR FINDINGS?

We were a little surprised to find minimal differences among different CRS fit conditions. We thought we might find more significant differences in the ATD responses between the ideal fit and the non-ideal fit conditions. So it appears that both CRS and vehicle manufacturers are designing robust systems that are forgiving even when the fit is not ideal, especially in the far-side impact scenario that we tested.

WHAT'S NEXT?

We want to build on this project and confirm our findings with more testing using different CRS and different vehicle fits. It might be worthwhile in the future to look at cases of CRS misuse as well.



VERTICAL VEHICLE KINEMATICS IN FRONTAL CRASHES – IMPLICATIONS FOR REAR ROW OCCUPANTS

Principal Investigator:

Matthew R. Maltese, PhD, Children's Hospital of Philadelphia

Students:

Seth Fein, University of Pennsylvania;

Joshua Snitzer, University of Pennsylvania

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Eric Dahle**, Goodbaby International; **Hiromasa Tanji**, TK Holdings Inc.; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT AND HOW WAS IT CONDUCTED?

We looked at how a vehicle's vertical movement during a front-end crash might affect rear row restraint performance. Sled tests of CRS typically simulate planar crashes, meaning all four of the vehicle's wheels remain on the ground. But, in full vehicle crash tests, the vehicle often moves vertically as well, pitching forward in a frontal crash. There is evidence that this vertical movement may alter how restraints interact with the body. We wanted to quantify how vehicles actually move in front-end crashes and use that information to design more effective restraints, particularly for the rear row.

Using publicly available data from NHTSA, we selected 100 crash tests of vehicles likely to be transporting children and conducted in-depth, high-speed video-based analyses.

WHAT DID YOU FIND?

There were several surprises. First, not all vehicles moved the way we thought they would. It has been generally believed that when a vehicle strikes a barrier head on, the back of the vehicle moves upward in the air. But not all vehicles do that—some actually pivot down.

Second, we found that the vehicle's center of rotation changed depending on the vehicle and varied over time. It has been generally believed that when a vehicle hits a barrier, its center of rotation is where the nose of the vehicle meets the barrier.

Third, it has been thought that the vehicle rotation occurs late in the crash; but, in about 30 percent of crashes, it actually occurs early in the event.

WHAT'S NEXT FOR THIS LINE OF RESEARCH?

Restraint systems, including CRS, are typically tested using a crash sled, where all four wheels of the vehicle remain on the ground during a crash. What we do not know is how the introduction of vertical motion will change test outcomes for rear-seated occupants. To see how much pitch matters, we would like to conduct tests using pitching sleds that incorporate some of a vehicle's vertical motion.



Frontal crash test showing pitching motion of the rear of the vehicle, which places vertical loading on the rear occupants.



EVALUATION OF CRS AND VEHICLE FEATURES ASSOCIATED WITH IMPROVED TOP TETHER ATTACHMENT RATES

Co-Principal Investigator:

Julie Mansfield, MS, The Ohio State University

Co-Principal Investigator:

John Bolte IV, PhD, The Ohio State University

Students:

Gretchen Baker, The Ohio State University;

Kat Sikiric, The Ohio State University;

Sydney VerDow, The Ohio State University;

Yadetsie Zaragoza-Rivera, The Ohio State University

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Emily Thomas**,

Consumer Reports; **Phil Pryzbylo**, Goodbaby International;

Anthony Rossetto, FCA US LLC; **Mark LaPlante**, Graco Children's

Products Inc.; **Nick Rydberg**, Minnesota HealthSolutions;

Julie Kleinert, Emeritus Chair; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

The top tether on a forward-facing CRS is an important safety feature that prevents the CRS from tipping forward in a crash. Unfortunately, a lot of parents and caregivers forget to attach the top tether when they are installing the CRS. We recruited 96 adults to install CRS to test a few variables—including the color of the top tether, whether the top tether is labeled or not, and where the tether is stored on the car seat—to determine if those variables can make the top tether easier to see and more intuitive to use during CRS installation.

WHAT DO YOUR FINDINGS SHOW?

Many of the subjects consulted the CRS manual and the vehicle instruction manual for guidance. We found that parents who used LATCH to install the CRS tended to have higher attachment rates of the top tether as opposed to those who used the seat belt. This showed us that those who took the time to understand the different hooks and latches on a CRS tended to understand what to do with the top tether. That was certainly encouraging. However, overall, subjects' interpretation varied on how different parts of the CRS are supposed to be adjusted. There were no specific tether design features (such as tether color, labeling, or storage location) that resulted in consistently better tether attachment rates.

WHAT HAPPENS NEXT WITH THIS PROJECT?

We will share our findings with industry representatives in CChIPS. Attaching the top tether is such an easy and beneficial thing to do, but a lot of parents and caregivers do not realize it exists or do not know what to do with it. We want to make the top tether a little more intuitive for them to use. We plan to brainstorm with the industry representatives about changes we can make to the CRS in order to improve top tether attachment rates and child safety.

ACCEPTABLE (66)

NO ERRORS (50)	MINOR ERRORS (16)
Identified Tether ✓	Loose (11)
Connect Anchor ✓	Twisted (2)
Route Under Head Restraint ✓	Around Head Restraint Post (1)
Flat Webbing ✓	Around Head Restraint Post and Twisted (1)
Tension ✓	Over Folded Head Restraint (1)

UNACCEPTABLE (30)

MAJOR ERRORS (10)	NOT USED (20)
Attached to Back of Child Restraint System (4)	Did Not Know it Existed (9)
Attached to Lower Anchor (3)	Did Not Know How to Use It (7)
Routed in Front of Seat Back (2)	Seemed Optional (3)
Attached to Seat Stow Handle (1)	Attached a Lower Anchor to Tether Anchor (2)

Tether usage outcomes were dichotomized into “Acceptable” and “Unacceptable” categories. It should be noted that many of the “Acceptable” tether outcomes still had other installation errors in the lower anchors or seat belt.



EVALUATION OF VARIABILITY IN FIVE-POINT HARNESS TIGHTENING PROCEDURES

Co-Principal Investigator:

Julie Mansfield, MS, The Ohio State University

Co-Principal Investigator:

John Bolte IV, PhD, The Ohio State University

Students:

Gretchen Baker, The Ohio State University;

Stephen Rudolph, The Ohio State University

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Eric Dahle**, Goodbaby International; **Yibing Shi**, FCA US LLC; **Lan Xu**, FCA US LLC; **Kendal Fowler**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Jason Stammen**, National Highway Traffic Safety Administration; **Hiromasa Tanji**, TK Holdings Inc.; **Julie Kleinert**, Emeritus Chair; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

This study aimed to establish a method for CRS test engineers to tighten the harness on the CRS consistently. If you are testing 10 CRS in a day, you need to ensure they are all set up identically so that variability in harness tension does not influence the crash test results.

HAS THIS BEEN A SIGNIFICANT CONCERN?

There is some suspicion in the industry that it might be a problem. Unfortunately, variations in crash test setup can come from several sources, such as different tension in the harnesses or seat belts or different angles at which the ATD or the CRS is positioned. Our industry representatives in CChIPS suggested studying harness tightening methods across different test facilities to improve the procedure.

HOW WAS THE STUDY CONDUCTED AND WHAT WERE THE FINDINGS?

We recruited seven different associates across four companies within CChIPS. At each of their facilities, they tightened the harness of a CRS using five different methods, with each person conducting a total of 100 different trials.

We found substantial variability in the repeatability of each harness tightening method. However, we discovered two promising tightening methods. One was a 3-prong tension gauge that is clipped onto the harness webbing and measures the tension in that portion of harness. It is a fairly reliable tool that produced repeatable results across different users. The users also liked having a tool that provided an objective reading.

A second somewhat effective method was the “two finger test” in which the operators simply slide two fingers underneath the harness to feel its tightness. The reproducibility for this method was poor, which means that different people have different ideas about how tight is tight enough. However, once users established a feel for their target tension, they were able to produce similar tension trial after trial.

We are hoping these results can help create more harmonization across different facilities and perhaps even establish a better standard for harness tightening procedures.

	FMVSS 213	3-Prong	R44/R129	Two finger	Pinch
Tension magnitude?	Mid-range	Variable based on target	Very low	Variable based on experience	Variable based on experience
Repeatability	Moderate	Good	Good	Good	Moderate
Reproducibility	Good	Moderate	Poor	Poor	Moderate
Coefficient of variation	Moderate	Moderate	Poor	Moderate	Moderate
Ease of use	Poor	Good	Moderate	Good	Good
Confidence in consistency	Poor	Good	Good	Good	Moderate

Five different harness tightness assessment methods were analyzed in this study. The 3-prong gauge procedure ranked well in all categories and can be modified easily to produce different target tensions. The two finger method was repeatable within subjects but inter-subject reproducibility was not ideal. The FMVSS 213 method produced mid-range tension magnitudes but ranked low for ease-of-use and user confidence.



USABILITY OF NON-STANDARD LOWER ANCHOR SPACING FOR CRS INSTALLATIONS

Principal Investigator:

Julie Mansfield, MS, The Ohio State University

Students:

Morgan Jenkins, The Ohio State University;

Laura Jurewicz, The Ohio State University;

Yadetsie Zaragoza-Rivera, The Ohio State University

IAB Mentors:

Keith Nagelski, Britax Child Safety, Inc.; **Eric Dahle**, Goodbaby International; **Emily Thomas**, Consumer Reports; **Audrey Eagle**, FCA US LLC; **Anthony Rossetto**, FCA US LLC; **Mark LaPlante**, Graco Children's Products Inc.; **John Combest**, Nissan Technical Center North America Inc.; **Lorrie Walker**, Safe Kids Worldwide; **Hiromasa Tanji**, TK Holdings Inc.; **Schuyler St. Lawrence**, Toyota USA; **Barbara Birkenshaw**, Volkswagen Group of America; **Julie Kleinert**, Emeritus Chair; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Most passenger vehicles include a LATCH system, which has two lower anchors 11 inches apart that are used to attach a CRS. Typically, two different sets of these anchors are located in the two outboard seat positions. However, the center seating position has been proven to be safer for children in a CRS because it keeps them away from the doors and intrusions into the vehicle in the event of a crash. Many parents want to use the LATCH hardware that already exists in the inboard side of the outboard seat positions to attach the CRS in the center position, but this means the two lower anchors are no longer 11 inches apart.

WHAT DID THE STUDY FIND?

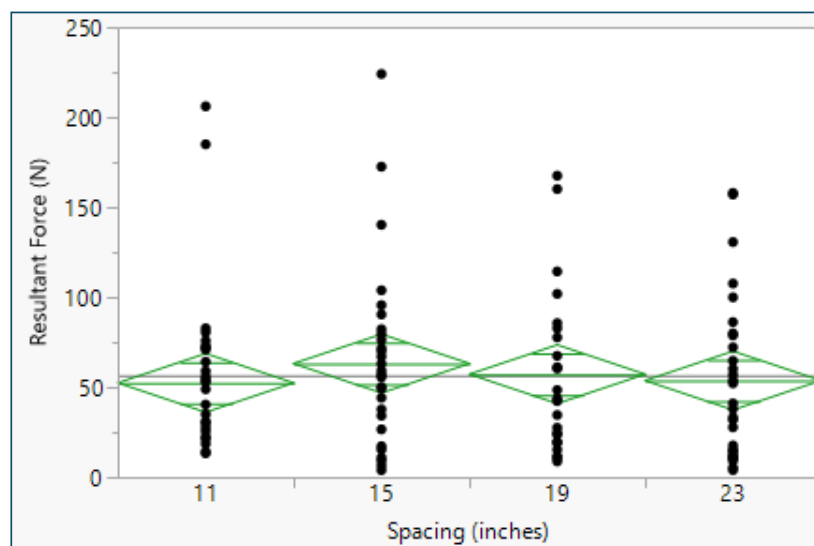
Parents and caregivers tested three different types of CRS in four different scenarios of lower anchor spacing. For two out of the three CRS models, the lower anchor spacing did not make any difference. Parents and caregivers were able to produce essentially the exact same amount of tension regardless of how the lower anchors were spaced.

For the third type of CRS, an infant seat, we found that more tension was needed in the lower anchor strap when used in the wider lower anchor configuration. Caregivers typically did not produce enough tension in any of the spacing conditions, but they did trend toward higher tensions when higher tensions were needed.

These outcomes should be considered in tandem with a [2017 CCHIPS study](#), led by Dr. Aditya Belwadi at CHOP, that conducted crash testing to evaluate the performance of the car seat when installed using these configurations.

WHAT ARE THE IMPLICATIONS FOR THESE FINDINGS?

These findings show that caregivers' installation skills are not very sensitive to lower anchor spacing. In other words, we would not expect to see an increase in CRS misuse if caregivers began installation in non-standard lower anchor seating positions. However, many caregivers do not install a CRS tightly enough in any condition, which can have serious safety implications on child passengers.



There were no significant differences in the amount of lower anchor strap tension (i.e., resultant force) that volunteers used to install the CRS in four different lower anchor spacing configurations (11, 15, 19, and 23 inches apart).



PARENTAL DRIVING BEHAVIORS OF CHILD PASSENGERS AGES 4-10 YEARS

Principal Investigator:

Catherine McDonald, PhD, RN, FAAN, University of Pennsylvania and Children's Hospital of Philadelphia

Co-Principal Investigators:

Linda Fleisher, PhD, Children's Hospital of Philadelphia;
Mark Zonfrillo, MD, MSCE, Hasbro Children's Hospital/Brown University

Students:

Roxanne Esquivel, University of Pennsylvania;
Erin Kennedy, University of Pennsylvania;
Vanessa Le, Temple University;
Kehinde Oyekanmi, Temple University;
Devan Russo, Temple University;
Maggie Staubel, University of Pennsylvania

IAB Mentor:

Jon Sumroy, mifold



WHAT WAS THE PURPOSE OF THIS PROJECT?

We focused on situational use of child restraint systems (CRS) and distracted driving behaviors among parents and caregivers of children ages 4 to 10 years. We wanted to better understand why some parents and caregivers do not always use the appropriate CRS, particularly booster seats.

Because risky behaviors sometimes coexist, we also looked at other risky driving behaviors, such as distracted driving.

HOW DID YOU CONDUCT THE STUDY?

We conducted an online survey to collect data on caregiver utilization of CRS, carpooling behaviors, and distracted driving behaviors. Following recruitment through the TurkPrime platform, our final sample included 783 participants.

WERE THE RESULTS WHAT YOU EXPECTED?

Two major findings were a bit surprising. First, parents reported being more willing to not fully buckle their child into his or her CRS in practical situations. For example,

parents who used a booster seat for their child were more willing to have their child not fully buckled into the CRS than those that used the CRS in situations involving rental cars, driving "just around the corner," when there were not enough CRS in the car, or when the child was in someone else's car.

Second, we were surprised at the level of cell phone use by parents and caregivers while driving. Half of the parents and caregivers surveyed engaged in cell phone-related distracted driving while children were in the car. About 42 percent made hands-free calls and 35 percent hand-held calls, while 35 percent read texts and 25 percent sent texts.

WHAT WILL YOU DO WITH YOUR FINDINGS?

We are interested in using these preliminary data to design interventions to reduce risky driving behaviors. I think it also presents an opportunity to engage with parents in the healthcare setting; clinicians caring for children in this age range can improve awareness among parents around when and how to use a CRS, as well as how to help their teens reduce distracted driving behaviors.



EFFICACY OF AUTOMATIC EMERGENCY BRAKING DURING SHRP2 REAR-END CRASHES

Principal Investigator:

Thomas Seacrist, MBE, Children's Hospital of Philadelphia

Co-Principal Investigator:

Helen Loeb, PhD, Children's Hospital of Philadelphia

Student:

Ridhi Sahani, Bucknell University

WHAT WAS THE PURPOSE OF THIS PROJECT?

The Strategic Highway Research Program 2 (SHRP2) is a large naturalistic driving study that recorded information from vehicles driven by 3,000 drivers over two years. SHRP2 ended in 2015 and, at that time, none of the vehicles involved in the study had automatic emergency braking (AEB). Therefore, the goal of this study was to look at the rear-end crashes in the SHRP2 database and re-create them using a mathematical simulation as if the vehicles had AEB.

WHY DID YOU FOCUS ON THIS ISSUE?

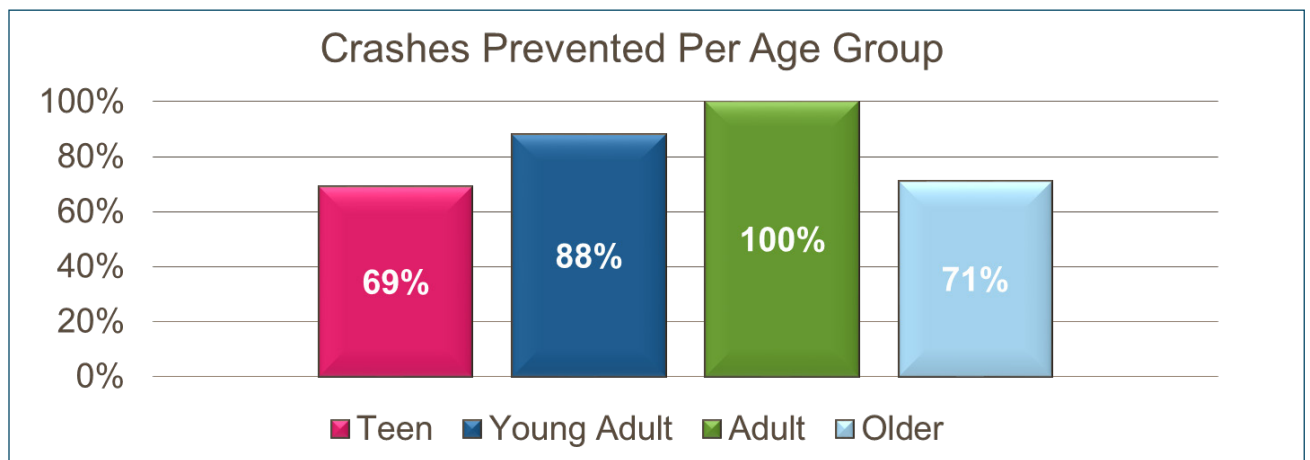
The most common crash scenario is when the case vehicle impacts the rear of another car, which is particularly troublesome for drivers at higher risk of crashing, including teens. Previous SHRP2 research found teens tend to be involved in rear-end crashes up to 10 times more often than experienced adult drivers. We wanted to see how effective AEB might have been in preventing these drivers from getting into rear-end crashes.

WHAT DID YOU FIND AND WERE ANY OF THE RESULTS SURPRISING?

We found AEB to be very effective; it would have prevented up to 79 percent, or 31 of the 39 rear-end crashes simulated in this project. Previous studies estimated that AEB would prevent up to 57 percent of the crashes and injuries but did not include the real-world data that SHRP2 provides, such as the exact speed of the vehicle, what the driver was doing at the time, and road conditions. So, our findings were a pleasant surprise. However, we did find that AEB was less effective during high-speed crashes or in bad weather.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THESE FINDINGS?

We hope automotive manufacturers will use the results to improve AEB to prevent crashes at higher speeds and in inclement weather. More importantly, we must also ensure that these vehicles with AEB get into the hands of teen drivers; this will require educational and promotional campaigns with teens and parents.



This graph highlights the percentage of rear-end crashes simulated to be preventable by AEB by driver age group.

SUPPLEMENTAL RESEARCH FUNDING

AWARE: ACCELERATING MINORITY ENTREPRENEURS IN HEALTHCARE

Principal Investigator:
Linda Fleisher, PhD, MPH

Funder:
National Science Foundation (NSF)

The goal of the AWARE pilot grant was to conduct a mixed methods assessment with women and underrepresented minority entrepreneurs to determine the barriers and facilitators to federal innovation grant submissions. This extensive needs assessment has provided critical insights about the needs of these underrepresented entrepreneurs and strategies to address considerable barriers. In fact, assessment results have been foundational to the development of “A Seat at the Table,” a chapter in the online publicly available resource on academic entrepreneurship developed by the University of Pennsylvania and Children’s Hospital of Philadelphia. The next step is to develop a prototypic technology platform that educates, supports, and mentors women and minority entrepreneurs and creates a pathway to increase diversity in the marketplace.

ANALYSIS OF THE RESPONSE OF SHIELD-BASED CHILD RESTRAINTS WITH HUMAN BODY MODELS

Principal Investigator:
Aditya Belwadi, PhD

Funder:
Goodbaby International

This project explored and built upon the first open source human body finite element model of a 6-year-old, PIPER. In this project, the model was scaled down to a 3-year-old to understand responses in a shield child restraint. Responses of the PIPER model were compared to a traditional 3-year-old Q series ATD in frontal impacts.

MOTION AND MUSCLE ACTIVATION OF YOUNG VOLUNTEERS IN EVASIVE VEHICLE MANEUVERS

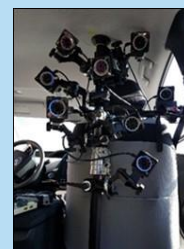
Principal Investigator:
Kristy Arbogast, PhD

Co-Investigator:
Julie Mansfield, MS

Lead Co-Investigator:
Valentina Graci, PhD

Funder:
Toyota Collaborative Safety
Research Center

This project examined responses of rear seat occupants to emergency maneuvers in a real vehicle rather than in a laboratory setting. In partnership with The Ohio State University Injury Biomechanics Research Center and the University of Virginia Center for Applied Biomechanics, the research team conducted an on-road (test track) assessment using professional drivers where video, electromyography (EMG, a measure of muscle activity), and motion capture data were captured on rear seat restrained occupants age 6 years and older. Four evasive vehicle maneuvers were tested: slalom, constant radius turn, automated braking, and manual emergency braking. Preliminary results show different neuromuscular control and bracing strategies in children versus adults. The ultimate goal of this project is to optimize vehicle restraint and seat design to provide protection in these common real-world scenarios.



On the top, the cameras of the 3D motion capture system were placed to obtain kinematic data of the right rear occupant. On the bottom, subject instrumentation.

PREPARING FUTURE INDUSTRY SCIENTISTS

Research Experiences for Undergraduates (REU)

The Center for Injury Research and Prevention (CIRP) at CHOP was awarded an NSF REU Injury Science Site grant, with an emphasis on providing research experiences to racial and ethnic minorities who are underrepresented in research, students with disabilities, women, and students from STEM-limited schools with limited internship opportunities and no available doctorate program. In our sixth summer offering this program, we received over 330 applications for 11 REU internship positions. The diverse

group of student scholars selected from schools across the country spent the summer working with CIRP researchers and receiving mentorship and hands-on research experience, as well as formal training in research ethics, research methodology, and presentation of research findings. Several students also had the opportunity to shadow clinicians at CHOP, one of the nation's top children's hospitals. Several of these students worked on CChIPS projects with CChIPS faculty.



Injury Biomechanics Symposium

The CChIPS site at The Ohio State University has been a leader in student development in injury biomechanics via the annual Injury Biomechanics Symposium (IBS). The IBS stimulates and rewards strong injury biomechanics research among trainees by providing a welcoming atmosphere for novice researchers to present original work in a non-threatening environment. In May 2018, it hosted more than 120 attendees, including 30 student presenters from 14 universities. Among the presenters were Ethan Douglas, a Master's student at CHOP/Penn who presented on the "Motion and Muscle Activation of Young Volunteers in Evasive Vehicle Maneuvers" project (see project summary on Page 16), Jalaj Maheshwari, MS, a student intern at CHOP who has worked on several CChIPS projects with Dr. Aditya Belwadi, and Yadetsie Zaragoza-Rivera, a PhD student at OSU working on the [Validation of a Custom Head Fixture for Pediatric Cervical Spine Strength and Stiffness Assessment project](#) which began during the 2016-2017 CChIPS project year.



Ethan Douglas (far right, middle row), Yadetsie Zaragoza-Rivera (fourth from right, front row), and Jalaj Maheshwari (fourth from right, back row) are pictured with fellow student presenters.

CChIPS: A Unique Consortium

The Center for Child Injury Prevention Studies (CChIPS) would like to thank the Industry Advisory Board (IAB) members, our member companies, and the National Science Foundation (NSF) for their generous support and insight.

Our vital work would also not be possible without the generosity of our academic, corporate, and government collaborators. Many thanks to Children's Hospital of Philadelphia; The Ohio State University; The University of Pennsylvania; Drexel University; Hasbro Children's Hospital/ Brown University; and the Virginia Tech Transportation Institute for providing CChIPS with forward-thinking scientists committed to making the world a safer place for children and adolescents.

Acknowledgements

This report was produced by the Center for Child Injury Prevention Studies (CChIPS) at Children's Hospital of Philadelphia (CHOP) and the Research Communications Department of the Children's Hospital of Philadelphia Research Institute.

Editor

Lindsey Mitros

Graphic Designers

Melissa LaVigne

Alexis Arvanitides

Production Manager

Christine Norris

CCHIPS LEADERSHIP TEAM

Flaura Winston

Kristy Arbogast

John Bolte

Lindsey Mitros

Arrianna Willis

Kevin Heller

Megan Fisher-Thiel

Patricia Harris

Karen Garnett

Tatijana Taylor

Be Part of a Safer Future

Additional partnerships are needed to successfully and efficiently reduce the burden of child injury. CChIPS looks to broaden its membership by adding new companies and other organizations vested in child safety and seeks to expand its scientific collaboration by linking with new academic partners. If your organization is interested in being part of this exciting movement to address a significant societal problem, please contact us at cchips@email.chop.edu.

CONTACT CChIPS AT:
2716 South Street, 13th Floor
Philadelphia, PA 19146
215-590-3118
cchips.research.chop.edu