CChIPS | Center for Child Injury Prevention Studies

SAFE AND SOUND

PAVING THE WAY

2023 Annual Report

PARTNERING FOR SAFETY

Welcome to the CChIPS 2022-2023 Project Year!

The Center for Child Injury Prevention Studies (CChIPS) takes a unique approach to child safety research. For 18 years, 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

Julie Mansfield, PhD, Kristy Arbogast, PhD, Flaura Winston, MD, PhD, co-directors, CChIPS

Founded in 2005 with a grant from 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). Our Industry Advisory Board (IAB) comprises 15 member organizations from industry, advocacy, and government agencies.

In 2022-2023 the IAB funded 11 research projects across the Center's multiple domain research agenda. In this Annual Report, you will find highlights of conversations held with our principal investigators about their CChIPS projects, discussing a range of topics including project aims, results, and industry relevance. We hope this format allows the expertise, passion, and dedication of our research scientists to shine through. These conversations also illuminate just how important a role our IAB members play in the research process and the industry-academic collaborative spirit that makes CChIPS research so unique. As an added benefit, IAB members have access to the full technical research reports that contain more detailed data and analyses.

In addition, CChIPS – through its parent center at CHOP, the Center for Injury Research and Prevention (CIRP) – utilizes a team of outreach and communication experts who focus on translating CChIPS research findings into appropriate messages and materials for target audiences. This includes digital communication strategies to share information, such as social media, email blasts, and the cchips.research.chop.edu and injury.research.chop.edu websites. The two websites garnered over 215,000 page views in calendar year 2022.

The Center's research portfolio continues to cover our core areas of focus: child passenger safety, pediatric and young adult biomechanics, and young driver safety. Our efforts are also evolving to address current and future challenges in child and young adult injury prevention as guided by science and our IAB member companies. To this end, in spring 2023, CChIPS IAB members and CHOP and OSU scientists came together for a roundtable discussion to consider emerging topics of interest in the field, including: current gaps in occupant protection, pedestrians and other vulnerable road users, autonomous vehicles and Advanced Driver Assistance Systems (ADAS), consumer education and public policy, and teen driving. We are proud to provide a collaborative platform that pushes the envelope in working to improve child and adolescent safety.

In addition to this Annual Report, our CChIPS scientists continue to share research at numerous professional conferences throughout the world. Over the past year, CChIPS research was presented at key events such as the Association for the Advancement of Automotive Medicine, the Automotive Safety Council, the Protection of Children in Cars Conference, the SAE Government/Industry Meeting, and the SAE World Congress Experience. Look for our researchers at similar venues as we turn the page to 2024. We look forward to discussing mutual interests in protecting children, youth and young adults on our roads.

We are pleased to share our achievements over this past year and in years to come, as together, we improve the safety of our roads for youth.

IAB MEMBER COMPANIES (2022-2023)

◆ Founding IAB Member Company

★ 2023 ACIP Conference* Presenting Sponsor

★ 2023 ACIP Conference* Silver Sponsor

* Each year, CChIPS hosts the Advances in Child Injury Prevention (ACIP) Conference that convenes child occupant safety professionals from industry, government, and organizations involved in research and development, product design, and safety policy and regulation to hear the latest research in traffic safety for children and adolescents. In June 2023, we convened an audience of 30 organizations and shared wide-ranging results from CChIPS research, engaging in dynamic discussion with key stakeholders throughout the industry. For more information on ACIP, please visit cchips.research.chop.edu/events.

CChIPS Mission Statement

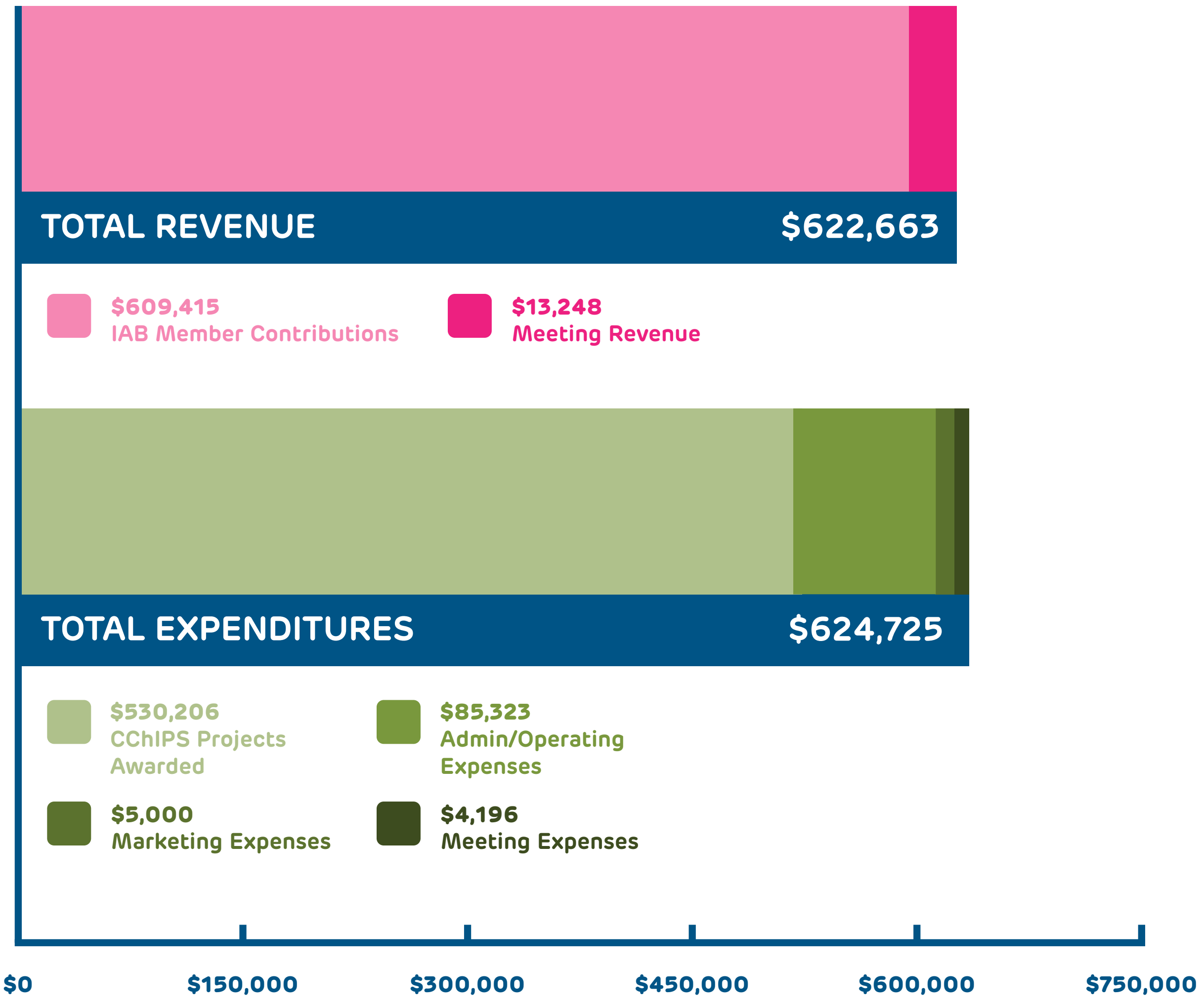
The CChIPS mission is to advance the safety of children, youth, and young adults by facilitating scientific inquiry into childhood and young adult injuries and to translate these findings into commercial applications and educational programs for preventing future injuries.

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

FUNDING THE RESEARCH

CChIPS is made possible through sponsorships from its Industry Advisory Board (IAB) members comprised of the leaders in industry, small business, nonprofits, and government agencies that engage in and value scientific research and development to improve child safety. For the 2022-2023 project year, each full voting IAB member contributed $65,000 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. All members contribute to the science as project mentors. Membership in CChIPS has fostered industry and small business commitment to the CChIPS mission and spurred innovation and collaboration. To become a member or to sponsor research with CChIPS investigators, please contact us at cchips@chop.edu.

REVENUE & EXPENDITURES FOR 2023



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
$65,000

Government/Nonprofit
$28,750

Small Business
$17,250

15 Members

$609,415 in research funds
excluding supplemental funds

The research pool funded 9 projects in 2022-2023, which fall within five interest areas. Projects are often categorized in more than one area.

Interest area	Projects	Value
Child Restraint Design and Performance	8 Projects	$801,687*
Consumer/Driver Behavior	4 Projects	$374,952*
Crash Avoidance & Autonomous Vehicles	3 Projects	$362,132*
Vehicle Restraint Performance	5 Projects	$550,997*
Dummy Biofidelity	2 Projects	$240,690*

What Does the CChIPS ROI Look Like for One Member?

In 2022-2023, a large business with an interest in vehicle restraint performance contributed $65,000 for access to research valued at $550,997.

* 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:

2022-2023 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 the five interest areas below.
Look for these icons next to each project summary.

- Dummy Biofidelity/Human Body Models
- 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

LODC – Large omni-directional child dummy, representing approximately a 10-year-old child

MEG – Magnetoencephalography, an advanced imaging method that allows measurement of brain functioning

REU – Research Experiences for Undergraduates summer internship program, sponsored by the National Science Foundation

EFFECTS OF HEAD RESTRAINT INTERFERENCE ON CRS PERFORMANCE IN FRONTAL AND SIDE IMPACTS

Principal Investigator:
John Bolte IV, PhD, The Ohio State University

Co-Investigator:
Julie Mansfield, PhD, The Ohio State University

IAB Mentors:
Jonathon Gondek, Calspan Corporation; **Emily Thomas**, Consumer Reports; **Suzanne Johansson**, General Motors Holdings LLC; **James Fitzpatrick**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Bill Lanz**, American Honda Motor Co., Inc.; **Susan Mostofizadeh**, American Honda Motor Co., Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Russ Davidson**, Lear Corporation; **Steve Gerhart**, Nuna Baby Essentials, Inc.; **Jennifer Pelky**, Toyota USA; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Previous compatibility studies and real-world experience have shown that forward-facing (FF) CRS and high-back belt positioning boosters (BPB) are often tall enough to contact the head restraint (HR) of the vehicle seat where they are installed. Having HR interference can create a gap behind the CRS or change the angle of the CRS on the vehicle seat. The goal of this study was to understand the dynamic effects of HR interference in frontal and far-side impacts.

HOW WAS THE RESEARCH CONDUCTED?

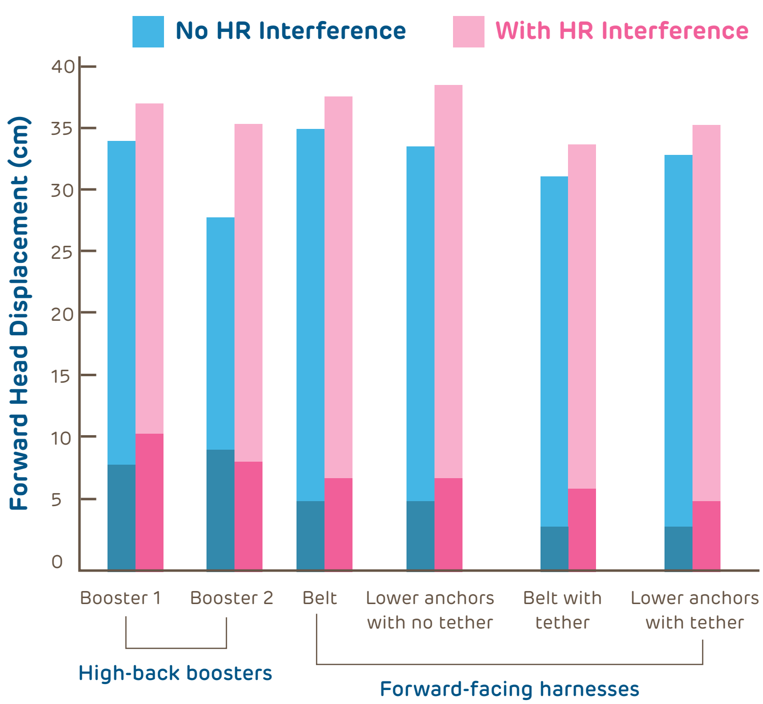
We ran a total of 24 sled tests (12 frontal impacts and 12 far-side impacts) using third row seats from a recent model year minivan. One FF CRS model and two different high-back BPB models were installed with and without HR interference by removing the HR for those tests. The FF CRS was installed using a variety of different methods (seat belt or lower anchor, with and without top tether) to see if the installation method would affect the outcomes. Our primary outcome metrics were ATD and CRS excursions as well as kinetic responses of the ATD.

WHAT DID YOU FIND?

In frontal impacts, the installations that had HR interference produced a small but consistent increase in most of the injury metrics, including frontal head excursion, head injury criterion (HIC), chest resultant acceleration, neck tension, neck flexion moment, and lap/shoulder belt loads. This difference can most likely be attributed to the HR initially positioning the CRS and occupant further forward on the vehicle seat. In the far-side impact tests, the results were less consistent. The presence of a top tether seemed to affect whether certain injury metrics were higher or lower with respect to HR interference.

WHAT'S NEXT?

This study showed that removing the HR to eliminate interference might reduce some injury metrics for CRS-seated children in frontal and far-side impacts. However, this study did not investigate rear impacts and the potential consequences of removing the HR in that crash mode, where support from the HR might be beneficial. It is not well documented whether the head support provided by the CRS or BPB alone would be sufficient in rear impacts. Future work in this area would create a more well-rounded dataset to help guide manufacturers' recommendations regarding HR positioning in conjunction with CRS.



In frontal impacts, HR interference caused the occupant's head to begin in an initially more forward position (~1.4 cm) on the vehicle seat (dark colored portion of the bars). During the crash event, the head displaced forward roughly equal amounts regardless of HR interference (light colored portion of the bars). Therefore, the overall forward head excursion (total height of each bar) was greater for CRS with HR interference, likely due to the more forward initial position of the head.

UNDERSTANDING SMALL OCCUPANT KINEMATIC RESPONSE IN RECLINED SEATS IN LATERAL OBLIQUE IMPACTS BY TESTING THE LARGE OMNIDIRECTIONAL CHILD (LODC) ANTHROPOMORPHIC TEST DEVICE (ATD)

Principal Investigator:
Valentina Graci, PhD, Children's Hospital of Philadelphia and Drexel University

Co-Investigators:
Hans Hauschild, MS, Medical College of Wisconsin;
John Humm, PhD, Medical College of Wisconsin;
Jalaj Maheshwari, MSE, Children's Hospital of Philadelphia

IAB Mentors:
Jonathan Gondek, Calspan Corporation; **Suzanne Johansson**, General Motors Holdings LLC; **Mark LaPlante**, Graco Children's Products Inc.; **Emily Burton**, American Honda Motor Co. Inc.; **James Fitzpatrick**, Graco Children's Products, Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Erin Hutter**, National Highway Traffic Safety Administration; **Schuyler St. Lawrence**, Toyota USA; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

This project aimed to expand our previous findings that showed belt-positioning booster seats prevent submarining (sliding under the seat belt) when a child dummy (LODC) is in a reclined seating position in a frontal crash. In this current project we characterized the kinematics and kinetics of a reclined, booster-seated LODC in far-side lateral-oblique crashes.

HOW WAS THE RESEARCH CONDUCTED?

The LODC was positioned in eight lateral-oblique sled tests, with and without a booster, and at three seat-back angles (nominal, moderate, and severe recline) to evaluate the injury and submarining risk of children in these conditions. The dummy was positioned in a far side position – away from the side of impact.

WHAT DID YOU FIND?

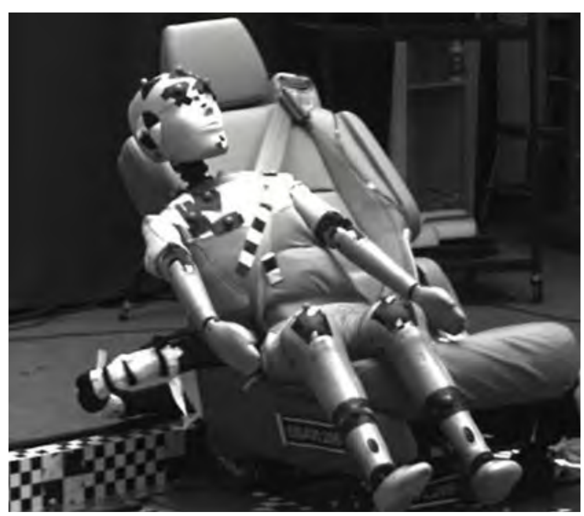
We saw several important advantages to having the children in booster seats, including lower abdominal pressure, chest deflection, neck lateral movement, pelvis and thoracic acceleration, and lumbar stress compared to non-booster seated children. However, the boosted children experienced greater head excursion and pelvis lateral rotation in far-side impacts, which is something to consider since in far-side impacts countermeasures such as the side air bag are too far away to provide protection.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

We hope that our findings provide useful information to vehicle manufacturers for restraint design, especially for children transitioning from a booster seat to just a seat belt alone. This study is an important step toward understanding how to keep children safe in a reclined position, which will become increasingly important as more autonomous vehicles are on the road.

WHAT'S NEXT?

It would be great to continue this line of research in non-injurious conditions with real children to better understand how they move both with and without a booster seat, as well as with and without a pre-pretensioner as part of the 5-point seat belt. This would provide even more information to move restraint design forward.

Test images of the LODC on a 45 degree reclined seatback angle during a lateral oblique impact before the LODC reached maximum head excursion: with the booster seat (left) and without the booster seat (right).

EFFECT OF A PRE-PRETENSIONER ON MOTION OF BOOSTER SEATED CHILDREN IN A PRE-CRASH MANEUVER

Principal Investigator:
Madeline Griffith, MSE, Children's Hospital of Philadelphia

Co-Investigators:
Valentina Graci, PhD, Children's Hospital of Philadelphia and Drexel University;
Thomas Seacrist, MBE, Children's Hospital of Philadelphia

IAB Mentors:
Jonathon Gondek, Calspan Corporation; **Emily Thomas**, Consumer Reports; **Suzanne Johansson**, General Motors Holdings LLC; **James Fitzpatrick**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Emily Burton**, American Honda Motor Co., Inc.; **Bill Lanz**, American Honda Motor Co., Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Russ Davidson**, Lear Corporation; **Nick Rydberg**, Minnesota HealthSolutions; **Erin Hutter**, National Highway Traffic Safety Administration; **Schuyler St. Lawrence**, Toyota USA; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?
Pre-pretensioners (PPT) are technology that tighten seat belts to reduce the slack before a crash. We have previously studied the effect of PPTs on adult occupants in the front seat, for whom they were primarily designed. This study assessed how well the PPT would work for children seated in belt-positioning booster seats in both optimal and naturalistic postures.

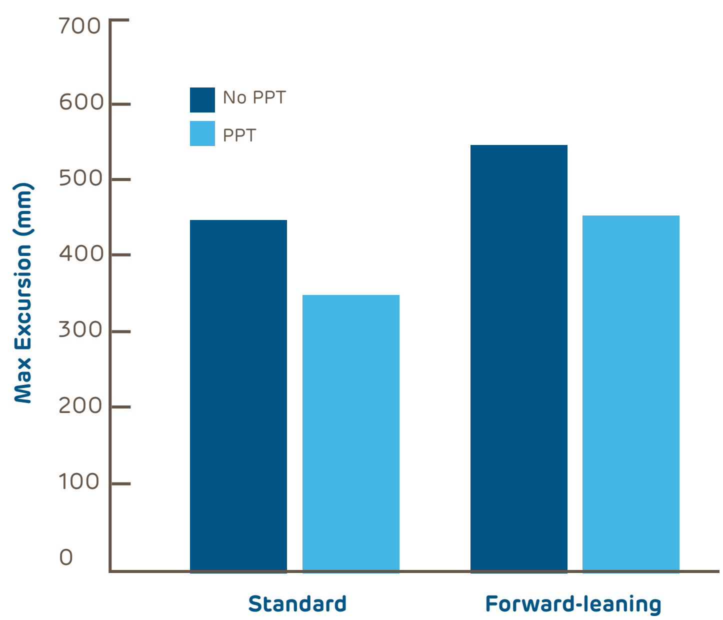
HOW WAS THE RESEARCH CONDUCTED?
We tested eight child volunteers ages 6 and 7 years with and without PPT in a low acceleration (1g) sled-simulated frontal-oblique (30°) impact. Participants were seated in both standard and forward-leaning postures before the impact event started. A 3D motion capture system, EMG (electromyography, a measure of muscle response), and seat belt load cells were used to capture kinematics, muscle activation, and seat belt loads.

WHAT DID YOU FIND?
We found that in both the standard and the forward-leaning postures, the PPT was effective at reducing maximum head and trunk displacements during these low-acceleration events, which is what we had hypothesized. Use of the PPT increased the proportion of the belt force that was carried by the shoulder belt. These findings suggest that the PPT may be an effective safety countermeasure for booster-seated children as well as adults.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?
Child seat manufacturers and vehicle manufacturers will benefit from the data provided in developing new rear-seat safety technology that is safe and effective for pediatric occupants.

WHAT'S NEXT?
We could compare the results from this study with our previous study on the PPT with adult occupants to quantify similarities and differences. Researchers may also want to study the effect of the PPT on children of different ages and restraint types.

Belt-positioning booster seated child volunteer in standard (left) and forward-leaning (right) postures.



Maximum forward excursion values for the trunk in the standard and forward-leaning postures without the PPT and with the PPT, showing a decrease in maximum excursion with the PPT in both postures.

QUANTIFYING THE Q3S ATD RESPONSES IN CRS HARNESS MISUSE CASES IN FAR-SIDE IMPACTS ON THE FMVSS 213 NPRM TEST BENCH

Principal Investigator:
Jalaj Maheshwari, MSE, Children's Hospital of Philadelphia

Co-Investigators:
Madeline Griffith, MSE, Children's Hospital of Philadelphia; **Declan Patton, PhD**, Children's Hospital of Philadelphia

IAB Mentors:
Jonathon Gondek, Calspan Corporation; **Daniel Wells**, Calspan Corporation; **Emily Thomas**, Consumer Reports; **James Fitzpatrick**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Curt Hartenstine**, Iron Mountains; **Erin Hutter**, National Highway Traffic Safety Administration; **Steve Gerhart**, Nuna Baby Essentials, Inc.; **Russ Davidson**, Lear Corporation; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

The efficiency of CRS is contingent on proper installation and use. Common CRS misuses involving the 5-point harness include loose straps and chest clip errors. We conducted this sled test-based research with "real-world" misuse scenarios where the harness is not set at the required tightness and the chest clip is not positioned at its correct position or is disengaged entirely. We sought to test scenarios that could help guide future CRS misuse prevention efforts.

HOW WAS THE RESEARCH CONDUCTED?

The Q3s ATD was restrained in a forward-facing CRS on the FMVSS 213 NPRM side impact test bench, subjected to far-side impacts. Harness misuse cases, including harness slack (tight and loose harness) and chest clip misuse (engaged in ideal and low positions; disengaged clip) were tested. We conducted a repeat test for each condition for a total of 12 tests and compared injury metrics across all conditions.

WHAT DID YOU FIND?

Lateral head excursion was significantly greater for the loose harness as compared to the tight harness. The ATD's head rolled out of the protective side wings of the CRS, irrespective of the harness slack condition tested. The degree of rollout varied: when the harness was tight, the ATD rolled along the CRS's side wing; when the harness was loose, the head was completely exposed outside the confines of the CRS. When the CRS cannot contain the ATD's head, there is greater potential for head strike and injury. The chest clip misuse conditions generally had higher injury metric values than the ideal conditions.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

By studying the potential implications for child injury based on real-world CRS use, we can develop better ways to prevent their misuse. The study provides data to justify future initiatives to prevent CRS misuse through both engineering advancements and/or public education efforts.

WHAT'S NEXT?

The next step would be to include investigation of near-side impacts where excess lateral head excursion and head rollout could result in head contact with the vehicle structures.

Head rotation and roll-out observed in far-side impacts for the tight harness (left) and loose harness (right) conditions.

BOOSTER FEATURES THAT INFLUENCE PEDIATRIC POSTURE AND COMFORT DURING EXTENDED TIME PERIODS

Principal Investigator:
Julie Mansfield, PhD, The Ohio State University

Student:
Rosalie Connell, BS, The Ohio State University

IAB Mentors:
Emily Thomas, Consumer Reports; **Suzanne Johansson**, General Motors Holdings LLC; **James Fitzpatrick**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Joseph Webb**, Graco Children's Products Inc.; **Bill Lanz**, American Honda Motor Co., Inc.; **Susan Mostofizadeh**, American Honda Motor Co., Inc.; **Kyle Mason**, Iron Mountains; **Russ Davidson**, Lear Corporation; **Wu Pan Zagorski**, Lear Corporation; **Nick Rydberg**, Minnesota HealthSolutions; **Steve Gerhart**, Nuna Baby Essentials, Inc.; **Anita Sabapathy**, UPPAbaby; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

As comfort is one of the leading factors in booster seat selection, this project investigated different design features of booster seats that may influence the way children sit. We were particularly interested in the presence of armrests and the height or overall profile of the booster and these features' specific influences on the behaviors of children over a 30 minute time period, which has not previously been investigated in a laboratory setting.

HOW WAS THE RESEARCH CONDUCTED?

This study included 30 children between the ages of 5 and 12. Each participant sat in two different seating configurations for 30 minutes each, resulting in a total of 60 trials over five different conditions (high or low profile booster, armrests or no armrests, or baseline).

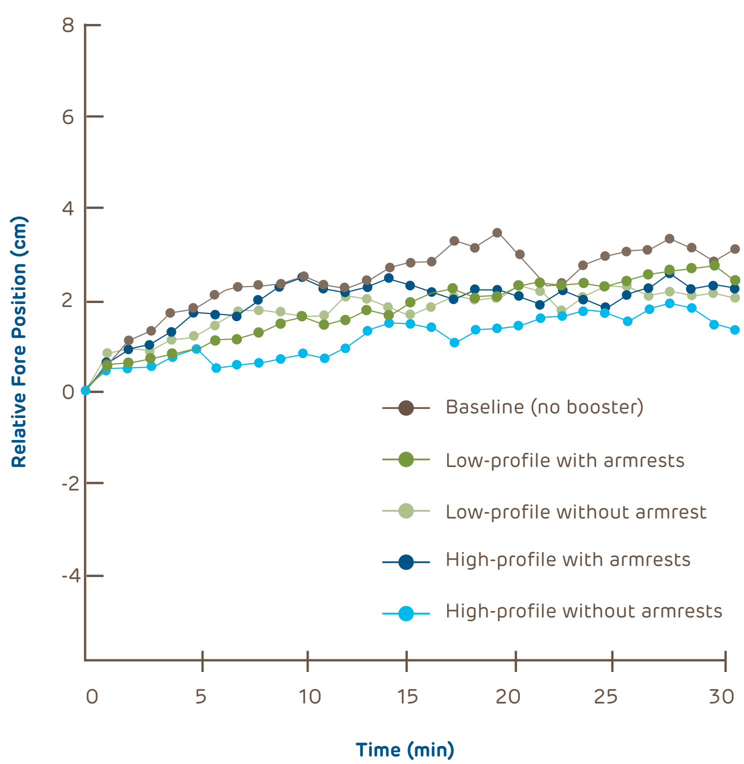
We analyzed video footage of children's behavior and measured how many times they moved or fidgeted in the booster, which is a quantifiable comfort metric called the Discomfort Avoidance Behavior (DAB) rate. We used a pressure mat along the seat surface to quantify shifts in each child's center of force (COF) along with wireless motion capture sensors to evaluate posture changes. We also gave surveys to children and their caregivers to understand their perception of the comfort of the child.

WHAT DID YOU FIND AND WAS ANYTHING SURPRISING?

The most surprising finding was the consistent outcome between the different booster types. While our study subjects varied greatly in terms of height, weight, and maturity level, all children tended to slide their hips forward over time and rotate their pelvises backwards, trending more toward a slouched posture over 30 minutes. Our assumption is that this was done to improve comfort, considering the comfort scores in their surveys didn't change over the 30 minutes. We did not find any evidence suggesting the armrests influenced comfort levels.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

These results indicate that booster selection goes beyond height and weight requirements; the maturity and behavior of the child can and should influence restraint choice to ensure optimal safety. It's also interesting for industry members to know we can quantify children's postures in boosters and use that information in further research or design improvements to try and mitigate the slouched posture we observed.



Average relative center of force (COF) position for each seating configuration. Time zero represents the upright, ideal, reference posture of each child. Positive values indicate the COF moving forward on the seat surface, indicative of slouching.

QUANTIFYING BELT TENSION IN CRS INSTALLATIONS WITH LOCK-OFF AND TENSIONING FEATURES

Principal Investigator:
Julie Mansfield, PhD, The Ohio State University

IAB Mentors:
Jonathon Gondek, Calspan Corporation; **Daniel Wells**, Calspan Corporation; **Suzanne Johansson**, General Motors Holdings LLC; **James Fitzpatrick**, Graco Children's Products Inc.; **Mark LaPlante**, Graco Children's Products Inc.; **Joseph Webb**, Graco Children's Products Inc.; **Curt Hartenstine**, Iron Mountains; **Kyle Mason**, Iron Mountains; **Nick Rydberg**, Minnesota HealthSolutions; **Erin Hutter**, National Highway Traffic Safety Administration; **Steve Gerhart**, Nuna Baby Essentials, Inc.; **Anita Sabapathy**, UPPAbaby

WHAT WAS THE PURPOSE OF THIS PROJECT?

Some CRS manufacturers are introducing seat belt lock-off or tensioning features designed to help consumers achieve tighter installations. Different designs appear to produce different levels of seat belt tension, although this has never been quantified across models. It is also not clear how consumers are interacting with these features or if they can use them correctly.

HOW WAS THE RESEARCH CONDUCTED?

We used an instrumented vehicle seat with a seat belt load cell to measure the amount of tension produced on the belt. Researchers installed 29 different CRSs several times each, producing sequentially increasing tension levels on the belt. Up to 70 installations were completed for each CRS for a total of over 1,600 installations.

Next, 30 adult volunteer participants each installed four different CRSs that had different types of lock-off/tensioning features or no additional features (i.e., baseline design). Following installation, the amount of seat belt tension was measured and any errors were recorded. We compared the volunteer participants' seat belt tension levels to both the range of values obtained by the researchers and the FMVSS 213 target ranges.

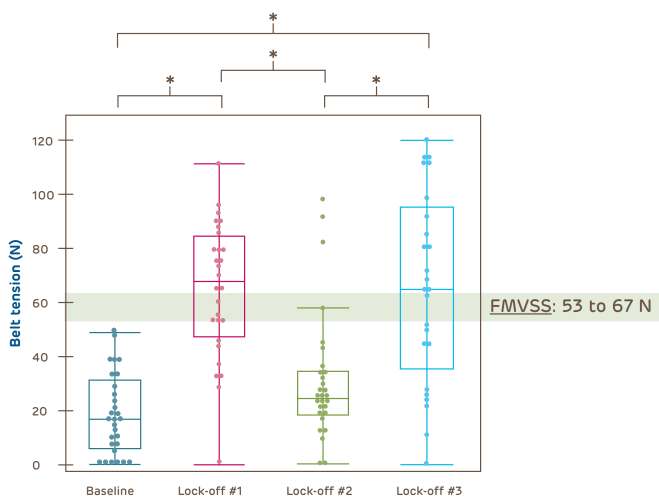
WHAT DID YOU FIND?

We found distinct differences among tension feature designs across CRS models: some added no additional tension while others added upwards of 250 N of additional tension to the installations. For the volunteer tests, we observed improvements in belt tension (within the desired FMVSS 213 range) for CRS models with features designed to add tension to the belt.

The lock-off only model was effective in locking the belt but did not improve overall belt tension levels. We also observed that the belt lock-off/tensioning features introduced some belt routing errors which were not present in the baseline CRS installations.

WHAT ARE THE INDUSTRY IMPLICATIONS?

Our results show that lock-off/tensioning features have the potential to help consumers perform snug, properly locked installations. Manufacturers should be mindful of how the instructions for these features are communicated to consumers. Clear labeling on the CRS and intuitive belt paths may help prevent caregivers from making belt-routing errors in these types of CRS.



The figure shows the final belt tensions produced during installations completed by 30 volunteer participants. The lock-off designs which produce additional tension on the belt (pink and light blue) resulted in significantly tighter installations compared to the non-tensioning lock-off (green) or the baseline CRS without lock-off (dark blue).

PHASE II: EPIDEMIOLOGIC INVESTIGATION OF CHILD RESTRAINT USE AND INJURY AMONG CHILDREN IN MOTOR VEHICLE CRASHES

Principal Investigator:
Rachel Myers, PhD, MS, Children's Hospital of Philadelphia

Co-Investigator:
Allison Curry, PhD, MPH, Children's Hospital of Philadelphia

Project Team Members:
Leah Lombardi, MPH, Children's Hospital of Philadelphia; **Melissa Pfeiffer, MPH**, Children's Hospital of Philadelphia; **Emma Sartin, PhD, MPH**, Children's Hospital of Philadelphia

IAB Mentors:
Emily Thomas, Consumer Reports; **Suzanne Johansson**, General Motors Holdings LLC; **Mark LaPlante**, Graco Children's Products Inc.; **Marianne Le Claire**, Graco Children's Products Inc. **Emily Burton**, American Honda Motor Co., Inc.; **Bill Lanz**, American Honda Motor Co., Inc.; **Russ Davidson**, Lear Corporation; **Steve Gerhart**, Nuna Baby Essentials, Inc.; **Guy Nusholtz**, Stellantis; **Schuyler St. Lawrence**, Toyota USA; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

This project builds upon prior CChIPS work using the New Jersey Safety and Health Outcomes (NJ-SHO) Data Warehouse in which we successfully linked NJ police crash report and hospital discharge data of child passengers across one year (2017) and demonstrated the potential use of these data for child-focused research. This preliminary work led to several critical questions related to child crash-related injury outcomes.

HOW WAS THE RESEARCH CONDUCTED?

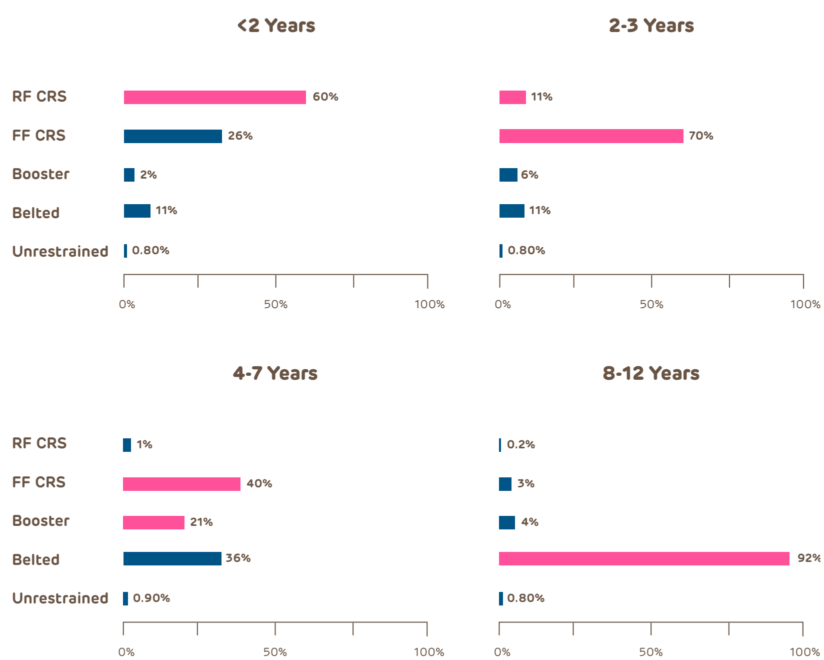
In the current project, we included two additional years (2018 and 2019) of crash and injury outcome data to conduct analyses across multiple years of motor vehicle crashes (MVCs). We described prevalence of child restraint use by child characteristics (age, sex, seating location, and crash injury) and driver characteristics (age, sex, restraint use, and alcohol use). We examined the frequency of injuries to child passengers documented on crash reports and in hospital discharge data.

WHAT DID YOU FIND?

We identified a sample of 87,229 child passengers ages 0 to 12 in MVCs in NJ from 2017-2019. While most children were seated in the rear rows of the vehicle, among children under 2, only 60% were riding in rear-facing CRS at the time of the crash, which goes against CPS best practices and NJ state law. We also found limited use of belt-positioning booster seats with potentially premature graduation to vehicle belt use, as shown by the proportion of 4-to 7-year-old's restrained by the vehicle belt at time of a crash (36%). We observed that younger (<21 years) and older (>65 years) drivers had greater proportions of improperly restrained children. With regards to injuries among child passengers, we found 12% of children noted to be uninjured on the crash report had an injury documented in the hospital data.

WHAT'S NEXT?

Our findings indicate that opportunities may exist for specific educational and behavioral interventions to address child restraint practices among certain potentially vulnerable groups, namely children under age 2, younger adult drivers, and drivers who engage in potentially unsafe behaviors. We are beginning to leverage the integrated data of the NJ-SHO to examine injury outcomes among child passengers using integrated hospital data to understand the types and severity of injuries associated with use of child restraints.



These graphs show the proportion of children using each restraint type by age. The bars in pink within each age category reflect the optimal restraint use by age per NJ statute and minimum best practice recommendations.

FRONTAL-OBLIQUE IMPACT SLED TESTS OF A REARWARD-FACING CHILD RESTRAINT SYSTEM WITH AND WITHOUT A SUPPORT LEG

Principal Investigator:
Declan Patton, PhD, Children's Hospital of Philadelphia

Co-Investigators:
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WHAT WAS THE PURPOSE OF THIS PROJECT?

This study continues a line of CChIPS research investigating support legs (sometimes referred to as load legs) as an anti-rotation device on CRS. Prior work has primarily focused on frontal impacts. Because side and oblique impacts are common real-world crash modes, the aim of this project was to quantify the head and neck injury metrics of an ATD in a rearward-facing (RF) CRS, with and without a support leg, in frontal-oblique impacts. To our knowledge, this study is the first to assess these types of crash configurations with a door structure.

HOW WAS THE RESEARCH CONDUCTED?

We conducted sled tests using the FMVSS 213 frontal crash pulse with a test bench that mimicked the rear outboard vehicle seat of an SUV. The door surrogate from the FMVSS 213a side impact seat assembly was rigidly attached to the sled deck adjacent to the test bench.

The test buck was rotated 30 degrees and 60 degrees relative to the longitudinal axis of the sled deck to represent frontal-oblique impacts, with the CRS and ATD seated nearside to the crash pulse. The 18-month-old Q-Series (Q1.5) ATD was seated in an infant RF CRS attached to the test bench with either rigid lower anchors or a three-point seat belt and tested with and without a support leg. A repeat test was performed for each condition for a total of 16 tests.

WHAT DID YOU FIND?

We found that the support leg significantly reduced head injury metrics and peak neck tensile force. In addition, the head contacted the door surrogate in the 60 degree tests without the support leg, but there was no head contact when the support leg was used. Our previous studies showed that the support leg provides benefit in terms of reducing those injury metrics in frontal crashes as well. With this study, we have now established that the benefit extends to oblique impacts. Additionally, rigid lower anchors were associated with significant reductions in head injury metrics and peak neck flexion moment compared to tests that attached the CRS with the seat belt.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

Our results add to a growing body of evidence regarding the protective benefits of CRS models with a support leg, which have reduced head injury metrics of pediatric ATDs studied across a range of scenarios.

A Q1.5 ATD seated in a rearward-facing infant CRS with a support leg attached with rigid lower anchors to the test bench with a door surrogate. The test buck is rotated 30° relative to the test sled.

STRENGTH OF UNDERFLOOR COMPARTMENTS WHEN LOADED WITH A SUPPORT LEG DURING A FRONTAL CRASH

Principal Investigator:

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Co-Investigators:

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WHAT WAS THE PURPOSE OF THIS PROJECT?

CRS support legs, also referred to as load legs, extend from the rear of the CRS to the floor of the vehicle and have been associated with a significant reduction of head injury metrics of pediatric ATDs during sled tests. As some vehicles have underfloor storage compartments in rear rows, there has been concern that installing a CRS with a support leg on top of these compartments may cause the compartment to collapse. The aim of this study was to investigate the strength of support legs from rear-facing (RF) infant CRS models against an underfloor storage compartment, with and without a foam filler, when subjected to loads simulating a frontal crash.

HOW WAS THE RESEARCH CONDUCTED?

We designed a drop test that simulated the vertical forces experienced by the support leg during FMVSS 213 frontal sled tests. An exemplar support leg from a RF infant CRS model was tested at peak reaction forces of 2.5-5.6 kN. Alternate support legs from the three additional RF infant CRS models were tested under the same conditions that resulted in a peak reaction force of 5.6 kN in the exemplar support leg.

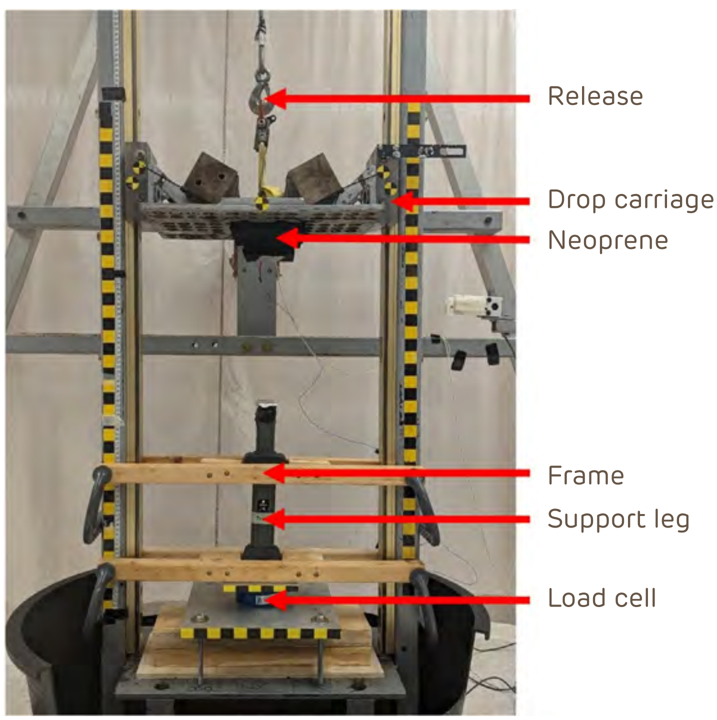
The reaction forces measured from these tests were applied via the exemplar support leg to the lids of an underfloor storage compartment across a range of peak reaction forces (2.5-5.6 kN), and residual deformation of the lid was measured. The lids were then loaded using the exemplar support leg for a peak reaction force of 5.6 kN with an expanded polystyrene foam filler placed inside the underfloor storage compartment.

WHAT DID YOU FIND?

The integrity of the exemplar support leg from the RF infant CRS model was maintained during all tests. The support legs from two alternate CRS models performed similarly to the exemplar leg; however, the support leg from the third alternate CRS model was compressed by 23 mm. In terms of the underfloor storage compartment lid, the residual deformation and the extent of cracking increased with peak reaction force, which we expected. However, the lid did not completely collapse in any of the tests, which has been previously reported as a concern. The foam filler reduced the average residual deformation of the lids by 67%.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

This is the first study to report the strength of CRS support legs or underfloor storage compartments when loaded by a CRS support leg. Our results demonstrate that a support leg can maintain integrity to effectively reduce the rotation of the CRS during frontal impacts unless it has been intentionally designed to partially collapse and attenuate some of that force. Our results support the recommendation of some vehicle manufacturers that a foam filler be used in an underfloor storage compartment if a CRS with a support leg is installed in the vehicle.



Test setup to measure the reaction force of the support leg using a load cell at the base of the drop rig.

UNDERSTANDING SOURCES OF DISPARITIES IN CHILD RESTRAINT SYSTEM BEHAVIORS

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WHAT WAS THE PURPOSE OF THIS PROJECT?

We know that disparities exist regarding who uses CRS appropriately (the best seat for a child's developmental stage) and correctly (installed in the vehicle the way it should be). Yet, we don't have a clear understanding of the factors driving these disparities. With this project, we wanted to investigate how sources of information, or where caregivers learn about child passenger safety (CPS) topics, may influence their appropriate CRS use.

HOW WAS THE RESEARCH CONDUCTED?

We conducted an online cross-sectional survey of 1,302 caregivers from 36 states about their CRS and booster seat use, as well as what information sources they thought were helpful in learning about CPS topics, such as their child's primary care physician, child passenger safety technicians (CPSTs); a car seat manual; family or friends; and online content.

WHAT DID YOU FIND?

It was heartening to see that the majority of (91%) of children were reported as appropriately restrained according to their age. However, we still noted disparities based on caregivers' characteristics (education, race/ethnicity, income). Echoing previous studies, we found information sources were not related to whether children were correctly restrained. Despite this, more caregivers, especially those who identified as Black, Hispanic, with less education or younger, had their kids appropriately restrained if they learned about CPS from pediatricians or CPSTs. Notably, caregivers from marginalized groups may have had limited access to these sources when compared to others surveyed.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

Together we can invest in more "boots on the ground" types of efforts to increase caregivers' access to desired experts, like training trusted community members as CPSTs and making online CPS content as easy to understand and access as possible for all. Additional training for pediatricians in CPS best practice recommendations and the importance of communicating this knowledge to marginalized groups may also be valuable.

IDENTIFYING KEY EYE-TRACKING METRICS ASSOCIATED WITH COGNITIVE CONTROL WHILE DRIVING, VALIDATED BY MEG NEUROIMAGING (YEAR 2)

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WHAT WAS THE PURPOSE OF THIS PROJECT?

Prior CChIPS work demonstrated we could detect cognitive control responses while driving among adults, typically developing teens, and atypically developing teens using our MEG+Driving+Eye-Tracking protocol. For this study, we wanted to advance this line of work by studying a more cognitively challenging task than the basic braking task already tested.

WHAT METHODS DID YOU USE?

We developed and added the more complex lead car-following task to the MEG+Driving+Eye-Tracking protocol, where the driver must follow a lead car at varying speeds, around curves, and in traffic and be prepared to brake at any time. Eye-tracking metrics were computed for periods of cognitive control (braking) and little to no cognitive control (coasting) and compared across the test sample of typically developing teens and teens with autism spectrum disorder (ASD).

WHAT DID YOU FIND?

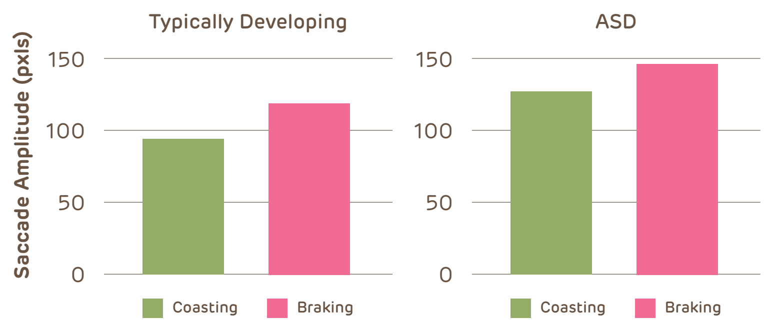
We detected differences in saccade (a rapid movement of the eye between fixation points) distance and velocity, as well as blink rate (frequency of blinks per minute) between periods of coasting and braking in both typically developing teens and teens with ASD. The eye-tracking behaviors of the teens with ASD, however, suggested a higher cognitive workload required to complete the simulated drives.

HOW ARE THESE RESULTS APPLICABLE TO INDUSTRY MEMBERS?

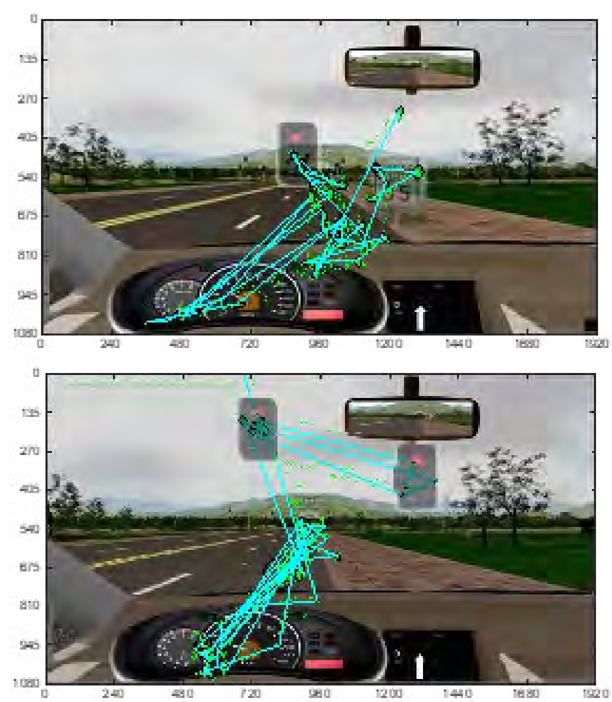
Our findings can be used to advance in-vehicle technology to help reduce driver errors and increase driver attention. With the cost of eye-tracking technology going down, it's possible that adding this technology to cars will soon become mainstream. By targeting cognitive errors, especially in young drivers, eye-tracking has the potential to prevent crashes.

WHAT'S NEXT?

To help us better understand changes in cognitive control neural responses and associated eye behavior, in Year 3 of this project we plan to add the unanticipated steering task to the simulated drive, which involves quick decision-making and precise motor control. We're also excited to collect more data in a larger sample.



The mean (±SE) saccade amplitude (distance traveled during a rapid movement of the eye between fixation points) exhibited by (left) typically developing adolescents compared to (right) adolescents with ASD over 20 repetitive trials during a lead car-following task.



Exemplar eye-tracking patterns for a typically developing teen (top) and an autistic teen (bottom) during the basic braking task. The blue lines represent saccades (a rapid movement of the eye between fixation points), and the green dots represent individual gaze points. The typically developing teen primarily focused on the road ahead and traffic lights when approaching an intersection. The autistic teen focused on the instrument panel and speed limit signs more than the typically developing teen.

PREPARING FUTURE INDUSTRY SCIENTISTS

Research Experiences for Undergraduates (REU)

The undergraduate students of CIRP's REU class of 2023.

The Center for Injury Research and Prevention (CIRP) at CHOP (the administrative home of CChIPS) hosts an NSF-supported Injury Science REU site, with an emphasis on providing research experiences to students who are underrepresented in research: American Indian/Alaskan Native, Black, and Latinx students, women, students with disabilities, and students from STEM-limited schools with minimal internship opportunities and no available doctorate program. In our 11th year offering this program, we received 174 applications for 9 REU internship positions for Summer 2023. The 10-week program included interactive workshops, seminars, and journal clubs. In addition, REU students were invited to participate in the CHOP Research Institute's Summer Scientific Research Colloquium, which included several virtual sessions designed for students to learn about scientific disciplines and research career paths. Some of this year's class elected to continue at CIRP, working on research projects remotely into the fall. Please contact us if you would like to meet with these talented students or are interested in sponsorship to extend this program to more students.

Injury Biomechanics Symposium

The CChIPS site at The Ohio State University is housed within the Injury Biomechanics Research Center (IBRC). The IBRC has been a leader in student development in injury biomechanics via the annual Injury Biomechanics Symposium (IBS). In its 18th year, 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 2023, it hosted the annual symposium as a hybrid in-person and virtual event. The event had over 165 registered attendees, including 30 student presenters from 16 universities around the globe. Keynote speakers included Jessica Jermakian, PhD from the Insurance Institute for Highway Safety and Suzanne Tylko, BScN, BScEng of Transport Canada. The speakers covered a range of topics, such as biomechanics of the spine, torso, and lower extremities, as well as full body response of postmortem human subjects, anthropomorphic test devices, and finite element human body models. Five student presenters from OSU shared their research: Timothy DeWitt, Danny Meringolo, Mukund Nadimpally, Ryan Lang, and Zachary Haverfield. They were joined by CHOP student presenters Andrew Duong from Drexel University and Bethany Williams, a 2022 CIRP REU student, from Louisiana Tech University (pictured above).

CChIPS Thought Leadership

CChIPS scientists continue to earn recognition as leaders in child occupant protection. Here is a sampling of awards received in 2022-2023:

- Declan Patton, PhD received the Best Paper Award from the Association for the Advancement of Automotive Medicine (AAAM) for 2022, awarded in 2023, for his CChIPS-funded work that examined the interaction between rear-facing CRS and the front row seatback.
- Valentina Graci, PhD received the Best Paper Award from the Association for the Advancement of Automotive Medicine (AAAM) for 2021, awarded in 2022, for her CChIPS-funded work that quantified important pulse characteristics for automatic emergency braking (AEB) systems.
- Kristy Arbogast, PhD received the 2022 Arnold W. Seigel International Transportation Safety Award from SAE International (pictured at top right).
- Flaura Winston, MD, PhD received the 2022 Robert Wood Johnson Foundation David E. Rogers Award (pictured at bottom right).
- Kristy Arbogast, PhD and Flaura Winston, MD, PhD were elected to the Manufacturers Alliance for Child Passenger Safety Hall of Fame in 2022.
- Julie Mansfield, PhD received the 2022 Elaine Wodzin Young Achiever Award from AAAM.
- Kristy Arbogast, PhD received the 2023 Award of Merit from AAAM.

CChIPS: A Unique Consortium

The Center for Child Injury Prevention Studies (CChIPS) would like to thank the Industry Advisory Board (IAB) representatives and our member companies for their generous support and insight. We would also like to acknowledge the National Science Foundation (NSF) for providing the support and infrastructure to establish CChIPS in 2005.

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; the Medical College of Wisconsin; and Drexel University for providing CChIPS with forward-thinking scientists committed to making the world a safer place for children and adolescents.

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