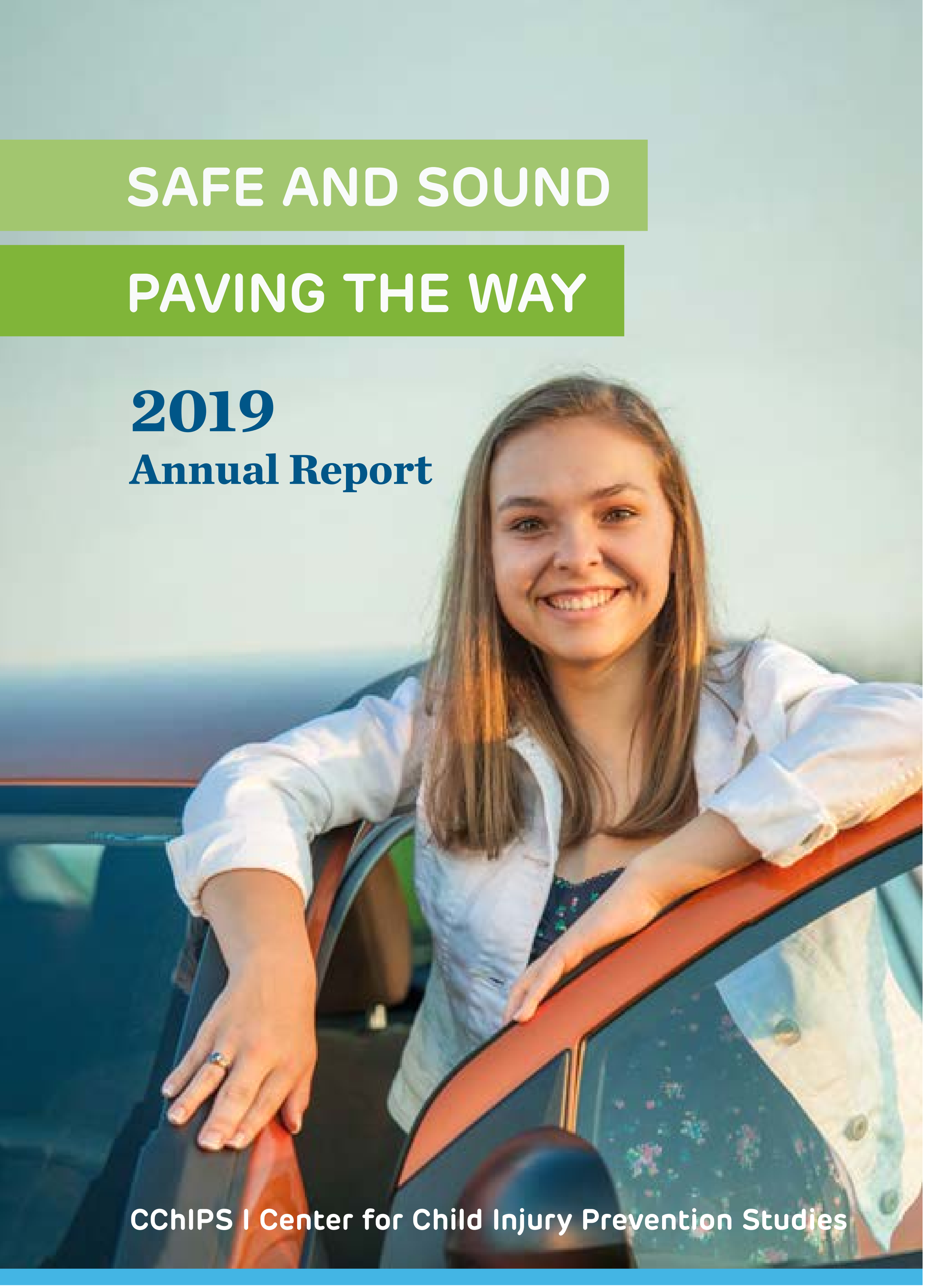
SAFE AND SOUND

PAVING THE WAY

2019
Annual Report



CChIPS I Center for Child Injury Prevention Studies

Children's Hospital of Philadelphia
RESEARCH INSTITUTE

The Ohio State University
WEXNER MEDICAL CENTER

PARTNERING FOR SAFETY

Welcome to the CChIPS 2018-2019 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). Our Industry Advisory Board (IAB) comprises 13 member organizations from industry, advocacy, and government agencies.

In 2018-2019, the IAB funded 11 research projects, bringing the Center's 14-year total to more than 150 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 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 have access to the full technical research reports that contain more detailed data and analyses.

The Center's research portfolio continues to cover our core areas of focus: child passenger safety, pediatric biomechanics, and young driver safety, while also evolving to address current challenges and emerging issues in child injury prevention, as guided by science and our IAB member companies. For example, a large CChIPS effort involved the evaluation of a new anthropomorphic test device, taking our biomechanics and testing research to the cutting edge.

In other CChIPS research, we are informing current and future efforts in optimizing Advanced Driver Assistance Systems and autonomous vehicles. CChIPS research is informing how young drivers, older drivers, and parents react to autonomous features, such as examining the safety of new vehicle seating configurations (e.g., swiveling) that may be possible in autonomous vehicles and how parents view the safety of their passengers under these conditions.

Our leadership in this space has continued beyond the confines of research projects: CHOP's Aditya Belwadi, PhD was named Autonomous Vehicle Special Interest Group Leader for the Association for the Advancement of Automotive Medicine (AAAM); Dr. Belwadi and CHOP colleagues Helen Loeb, PhD and Thomas Seacrist, MBE presented their research at the Automated Vehicles Symposium in Orlando, FL; and Kristy Arbogast, PhD, CChIPS co-director, presented to industry on important considerations for children and youth in autonomous vehicles at the Automotive Safety Council Annual Meeting in San Antonio, TX. Julie Mansfield, PhD, of OSU presented at the SAE World Congress in Detroit, MI and the AAAM Annual Conference in Nashville, TN, as well as at several state-wide conferences for Child Passenger Safety Technicians. We are proud to be a driving force behind innovative research that continues to push the envelope in working to improve child safety.

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 to translate CChIPS research findings into appropriate messages and materials designed to reach target audiences. They use 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 nearly half a million page views in calendar year 2018.

We look forward to sharing 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

Calspan · Consumer Reports · Federal Aviation Administration · FCA · GM · Graco · Honda · Humanetics · Lear Corporation · MinnHealth · NHTSA · Toyota · TRC

♦ Founding IAB Member Company

★ 2019 ACIP Conference* Presenting Sponsor

★ 2019 ACIP Conference* Sponsor – Gold

★ 2019 ACIP Conference* Sponsor – Silver

* Each year CChIPS hosts the Advances in Child Injury Prevention (ACIP) Conference that brings together 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. The next ACIP Conference will be held on June 17, 2020 in Plymouth, MI.

CChIPS Mission Statement

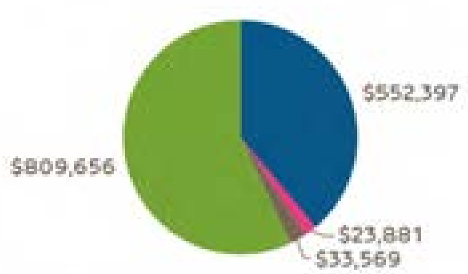
The CChIPS mission is to advance the safety of children, youth, and young adults by facilitating scientific inquiry into childhood and young adult injuries and to translate these findings into commercial applications and educational programs for preventing future injuries.

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 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. In 2018, 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 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.

REVENUE FOR 2019



Total Revenue: $1,419,503

- IAB Member Contributions
- NSF Center Award
- Meeting Revenue
- NSF Supplemental Funding

EXPENDITURES FOR 2019

Total Expenditures: $1,415,002

- CChIPS Projects Awarded
- Additional Projects Awarded (Additional Member Contributions & Supplemental Funding)
- Admin/Operating/Evaluator Expenses
- Meeting Expenses
- 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	Government/Nonprofit	Small Business
$65,000	$25,000	$15,000

13 Members

$552,397 in research funds
excluding supplemental funds

The research pool funded 9 projects in 2018-2019, which fall within five interest areas. Projects are often categorized in more than one area.

Child Restraint Design and Performance	Consumer/Driver Behavior	Crash Avoidance & Autonomous Vehicles	Vehicle Restraint Performance	Dummy Biofidelity
7 Projects	4 Projects	4 Projects	5 Projects	4 Projects
$538,716*	$414,542*	$357,120*	$386,389*	$257,890*

What Does the CChIPS ROI Look Like for One Member?

In 2018-2019, a large business with an interest in child restraint design and performance contributed $65,000 for access to research valued at $538,716.

* 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:

2018-2019 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/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

CHILD SEATS WITH LOAD LEGS: EFFECT ON HEAD INJURY RISK ACROSS CRASH DIRECTIONS

Principal Investigator:
Aditya Belwadi, PhD, Children's Hospital of Philadelphia

Co-Investigator:
Jalaj Maheshwari, MS, Children's Hospital of Philadelphia

Student:
Srihari Menon, University of Pennsylvania

IAB Mentors:
Jonathan Gondek, Calspan Corporation; **Mike Kulig**, Calspan Corporation; **Emily Thomas**, Consumer Reports; **Mark LaPlante**, Graco Children's Products Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Suzanne Johansson**, General Motors Holdings LLC; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

We quantified the response of a pediatric ATD in rear-facing CRS with and without load legs in frontal and oblique crashes. Load legs are structural supports that go from the base of the child seat to the floor of the rear row of the vehicle. Load legs are not new to CRS; they have been around in the European Union for close to a decade but have only been available in the US for the past five years. Load legs can lessen the impact of a frontal crash through energy absorption and rotation prevention. However, data were not only needed to prove that they work, but also how they work, to prevent injury during a crash.

WERE ANY OF THE RESULTS SURPRISING?

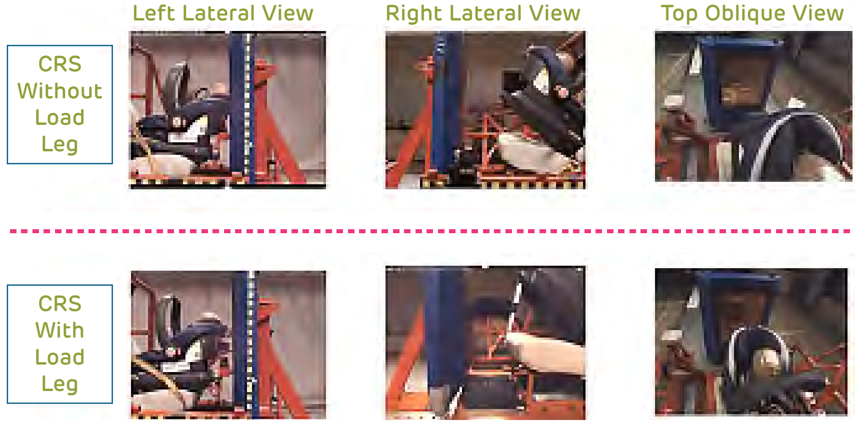
While we expected to see benefits of adding the load leg to CRS, it was a big surprise to see a 60 percent reduction in head injury criterion (HIC36) in a frontal crash with the load leg versus without it. That is substantial.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THESE FINDINGS?

We hope these findings will provide the evidence needed for broad adoption of load legs as part of CRS design across the industry. Currently, there are no regulations guiding manufacturers' use of load legs in the US.

WHAT HAPPENS NEXT WITH THIS PROJECT?

In Year 1 of this study, we looked at smaller rear-facing seats. We plan to now examine wider and bulkier CRS with load legs that are used to restrain older children up to 55 pounds. There is much more force on load legs when children are larger, but I still think that load legs will come out winning.



In a series of sled tests, rear-facing CRS with and without load legs were studied in frontal and oblique impacts.

LARGE OMNIDIRECTIONAL CHILD (LODC) ATD: ROUND ROBIN TESTING

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

Project Team Members:
Thomas Seacrist, MBE, Children's Hospital of Philadelphia; **Arrianna Willis, MS**, The Ohio State University

Students:
Rahul Akkem, Drexel University; **Gregory Chingas**, Drexel University; **Madeline Griffith**, University of Pennsylvania; **Christine Holt**, Drexel University

IAB Mentors:
Keith Nagelski, Britax Child Safety Inc.; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Jason Stammen**, National Highway Traffic Safety Administration

The LODC dummy representing a 10-year-old child is set up for a sled test.

WHAT WAS THE PURPOSE OF THIS PROJECT?

The Large Omnidirectional Child (LODC) is a new crash test dummy created by NHTSA to represent a 10-year-old child and will be used to test the safety of booster seats in rear seat configurations. This project allowed end users of the LODC ATD to be involved in its development by testing the device's performance and providing feedback to NHTSA.

HOW DID YOU CONDUCT YOUR RESEARCH?

Since NHTSA is a CChIPS member, linking its dummy development to the cohort of other IAB members made this project efficient and effective. Each IAB member company was able to have one or more of the LODCs at their facility over the past 18 months to run a variety of different tests – including certification tests, vehicle crash tests, sled tests, and even an airplane drop test.

They were also able to document and share information about how the ATD performed. This allowed both our research team and NHTSA to see the results of the dummy's testing in multiple labs under various testing conditions.

WHAT DID YOU FIND AND WHAT'S NEXT?

The preliminary findings highlight some durability issues with the dummy and identified changes that should be made to ensure the LODC can withstand repeated testing. The feedback from industry members will also allow for clarifications to be made to the LODC user's manual. The feedback and finalized data will ultimately be utilized by NHTSA to improve the overall biofidelity of the LODC.

LATERAL CERVICAL SPINE STIFFNESS IN CHILDREN

Principal Investigator:
Laura Boucher, PhD, ATC, The Ohio State University

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

Project Team Members:
Aditya Belwadi, PhD, Children's Hospital of Philadelphia; **Thomas Seacrist, MBE**, Children's Hospital of Philadelphia

Student:
Yadetsie Zaragoza-Rivera, The Ohio State University

IAB Mentors:
Yibing Shi, FCA US LLC; **Amanda Taylor**, Federal Aviation Administration; **Mark Neal**, General Motors Holdings LLC; **Michelle Schafman**, General Motors Holdings LLC; **Eric Dahle**, Goodbaby International; **Jerry Wang**, Humanetics Innovative Solutions; **Arjun Yetukuri**, Lear Corporation; **Russ Davidson**, Lear Corporation; **Hiromasa Tanji**, TK Holdings Inc.

WHAT WAS THE PURPOSE OF THIS PROJECT?

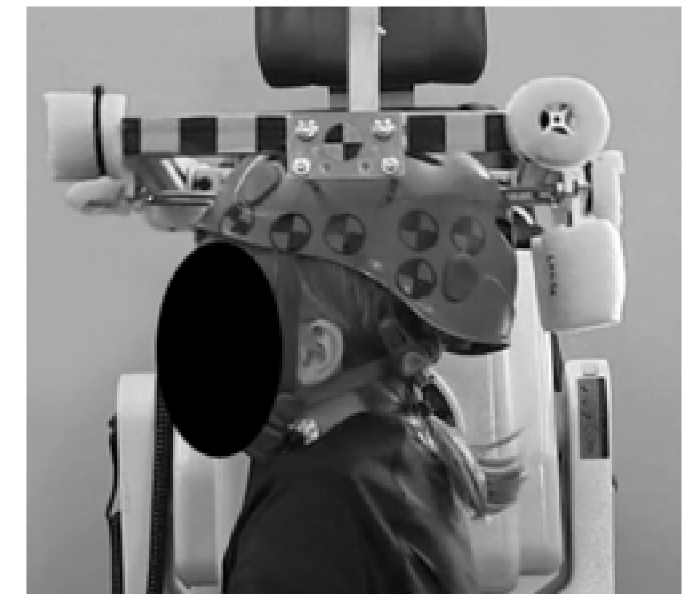
Human body models are often used in computer simulations when researching unique car crash scenarios or pedestrian crashes. Detailed data on neck range of motion, strength, and stiffness are extremely limited or do not exist at all for children, so this project aimed to gather those data to aid in improving the accuracy of pediatric human body models for computer simulations or dummy biofidelity assessments.

HOW WAS THE RESEARCH CONDUCTED?

We collected data from 25 male and female 5- to 7-year-old children to learn about range of motion, strength, and stiffness in their necks. Range of motion of the neck was measured using standard clinical techniques. Strength at discrete positions and stiffness over a continuous range of angles were measured using an isokinetic dynamometer fitted with a custom head fixture.

WHAT DID YOU FIND?

In the anterior-posterior direction, older children were stiffer in flexion compared to younger children. However, this same relationship was not observed in extension. When looking at overall motion, all children were significantly stiffer as they initially extended from a chin-to-chest position back to an upright position than in the latter portions of the motion. This was true for both the anterior-posterior and lateral directions of motion. Age differences in stiffness were not observed in the lateral direction for either left or right movements. Additionally, there were no differences in stiffness values between left and right movements.



Custom head fixture installed on the dynamometer. The volunteer is set up for testing neck strength and stiffness in flexion and extension. The child will push against the machine, moving it forward (neck flexion) and backward (neck extension) in a preset range of motion, and the machine will record the torque being produced.

WHAT ARE THE IMPLICATIONS FOR THESE FINDINGS?

Our results revealed it is important to consider initial position of the child during a simulation to correctly assign stiffness values to any model. Overall, children were less stiff when starting from a neutral position, as would be expected in a vehicle. This difference in stiffness might result in added vulnerabilities in automobiles for this young population. Additionally, with these data, we are creating a pediatric neck stiffness corridor that can be used to assess the current 6-year-old ATD neck response.

CAN THE STARTLE REFLEX BE MANIPULATED TO REDUCE TAKE-OVER TIME IN PRE-CRASH SCENARIOS FOR AUTONOMOUS DRIVING?

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

Co-Investigators:
Kristy Arbogast, PhD, Children's Hospital of Philadelphia;
Thomas Seacrist, MBE, Children's Hospital of Philadelphia

Project Team Member:
Jalaj Maheshwari, MS, Children's Hospital of Philadelphia

Students:
Rahul Akkem, Drexel University; **Madeline Griffith**, University of Pennsylvania; **Catherine Krawiec**, Rochester Institute of Technology; **Hanh Do Phung**, Drexel University

IAB Mentors:
Doug Longhitano, American Honda Motor Co., Inc.;
Kelly Funkhouser, Consumer Reports; **Emily Thomas**, Consumer Reports; **Arjun Yetukuri**, Lear Corporation; **Schuyler St. Lawrence**, Toyota USA; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Drivers of autonomous vehicles may be slow to take over vehicle control in time to avoid a crash. We wanted to understand if a novel take-over warning based on the startle reflex could accelerate take-over reaction times in adults and newly licensed teens. We also wanted to see how age and engagement in the driving task (ready to react versus texting while driving) influence the acoustic warning's effectiveness.

We placed seven adult drivers and seven teenage drivers on a lateral oscillating sled to undergo a simulation of pre-crash swerving events preceded by the acoustic startling warning (acoustic startling pre-stimulus, ASPS). They were initially seated with their hands on their laps and instructed to grab the steering wheel when the sled began to move.

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

We found that when adult drivers were ready to react, they lifted their hands from their lap towards the steering wheel more quickly and reduced their trunk and head lateral motion when exposed to the ASPS. In contrast, when exposed to the ASPS, the teens did not act faster and showed more lateral displacement than did the adults. We were surprised to find that our acoustic startling warning can "startle" adult drivers into a more advantageous position within the seat belt, in addition to accelerating hand motion toward the steering wheel.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

Our research can help industry to develop more effective take-over warnings. Since the ASPS activates later than forward collision warnings and lane departure warnings, it could be used in conjunction with those systems as a last resort if the driver does not respond to them. Our findings can be used to inform ADAS for all vehicles.

WHAT'S NEXT FOR THIS LINE OF RESEARCH?

Our first study only involved male drivers, and we want to find out if the startle reflex could be beneficial to female drivers as well. We also want to understand if the differences we observed with age – where adult drivers' movements were accelerated by the ASPS but those of teens were not – apply to females as well.

A custom sled apparatus exposed subjects to low-severity, non-injurious loading conditions that mimic pre-crash swerving events.

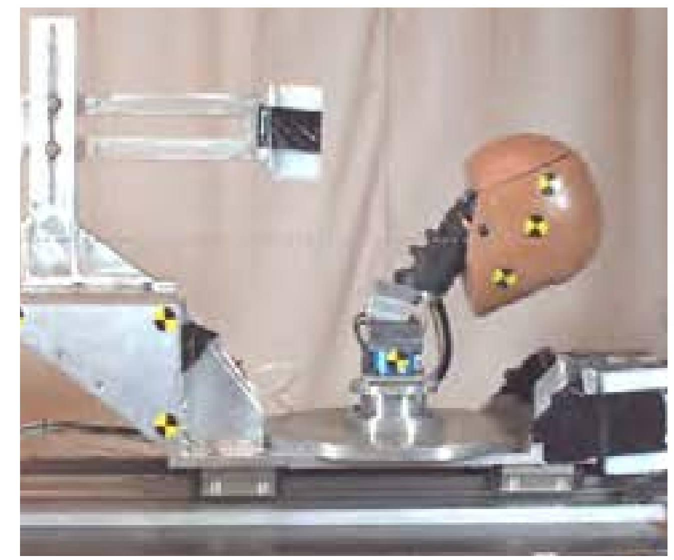
SENSITIVITY ANALYSIS ON FACTORS THAT INFLUENCE HEAD RESPONSES OF THE HYBRID III 6-YEAR-OLD ATD

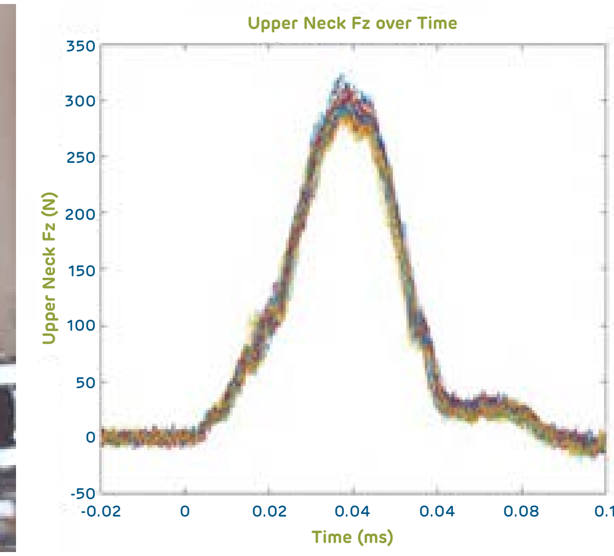
Principal Investigator:
Yun Seok Kang, PhD, The Ohio State University

Co-Investigator:
John H. Bolte IV, PhD, The Ohio State University

Students:
Reagan Di Iorio, The Ohio State University; **Talmadge Gaither**, The Ohio State University; **Kyle Kuchynsky**, The Ohio State University

IAB Mentors:
Mark La Plante, Graco Children's Products Inc.; **Russ Davidson**, Lear Corporation; **Jerry Wang**, Humanetics Innovative Solutions Inc.; **Jason Stammen**, National Highway Traffic Safety Administration; **Julie Kleinert**, Technical Advisor





The Hybrid III 6 year-old ATD head and neck experienced peak neck flexion during the baseline test with 2.0 in-lb neck torque set-up. The plot at right shows the repeatability of the upper neck tension force in the baseline tests over 30 repeated tests.

WHAT WAS THE PURPOSE OF THE PROJECT?

This project aimed to understand how the head and neck of the Hybrid III 6-year-old ATD respond to variability in the neck tension set-up and to determine repeatability over multiple tests. We know that head kinematics of the ATD can be influenced by different initial neck tensions, and repeated tests may change the tension level of the neck center cable, potentially changing the responses of the head. It is important for industry members to better understand the reliability of ATD performance during sled testing.

HOW WAS THE STUDY CONDUCTED?

We developed a mini-sled fixture to simulate a frontal impact scenario and subjected the ATD head and neck assembly to a velocity similar to FMVSS 213 sled tests. We then changed the neck tension to evaluate the sensitivity of the responses. For repeatability we ran over 30 tests.

WAS ANYTHING SURPRISING IN YOUR FINDINGS?

A pleasant surprise for us was that over the course of the 30 tests, all relevant head kinematics and upper neck kinetics showed excellent repeatability. However, these results should be considered as preliminary because we used a mini set-up and not the full sled. Future CChIPS work can utilize this methodology to run multiple tests with the full test sled set-up.

WHY ARE THE FINDINGS IMPORTANT?

Now that we have begun to confirm the repeatability of the Hybrid III ATD head and neck, if CRS and vehicle manufacturers have inconsistencies with data across multiple tests they can check other factors such as ATD posture and positioning, other ATD parts, or the CRS.

EMERGENCY AUTONOMOUS TO MANUAL TAKEOVER IN THE DRIVING SIMULATOR: TEENS VS. ADULT WARNING SYSTEM EFFECTIVENESS (YEAR 2)

Principal Investigator:
Helen Loeb, PhD, Children's Hospital of Philadelphia

Co-Investigators:
Aditya Belwadi, PhD, Children's Hospital of Philadelphia; **Chelsea Ward McIntosh, MS, CCRP**, Children's Hospital of Philadelphia

Students:
Chris Bijumon, Drexel University; **Jalaj Maheshwari**, University of Pennsylvania; **Hannah Milhorn**, University of Pennsylvania; **Saniyah Shaikh**, University of Pennsylvania; **Michelle Shen**, University of Pennsylvania; **Adin Solomon**, Drexel University; **Elliott Warshowsky**, Drexel University; **Max Weinstein**, Jack M. Barrack Hebrew Academy

IAB Mentors:
Yibing Shi, FCA US LLC; **Mark Neal**, General Motors Holdings LLC; **Melissa Miles**, State Farm Mutual Automobile Insurance Companies; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Current self-driving vehicles rely on the driver to monitor the road at all times and quickly take over when necessary. For this to work, the driver must stay engaged. To find out whether drivers remain engaged in self-driving vehicles, we studied 60 participants in three groups – teens (ages 16-19), adults (ages 30-55), and seniors (age 65+) – and had them take two simulated drives developed as part of Year 1 of this project. We also interviewed them about their perceptions of self-driving, both before and after participation.

The Realtime Technologies, Inc. HD self-driving simulator in automatic mode: The upper and lower left quadrants show a study participant in the driving simulator; the upper right quadrant shows an emergency situation that requires the driver to react; and the lower right quadrant shows the participant's foot under the pedal when seeing the emergency situation.

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

More than 75 percent of the drivers did not keep their hands on the steering wheel, and over 35 percent did not keep their foot either on or near the pedal. We also observed a high level of boredom, with a few participants even falling asleep at the wheel. What was surprising is that when asked to perform a task before an emergency situation, such as collecting change for a toll, participants seemed to come out of a lethargic state which led them to better react to the emergency situation. We think the 'distraction' woke them out of lethargy to put one hand back on the wheel and their foot back to the pedal.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THESE FINDINGS?

This study confirmed the need for industry to understand human factors in autonomous driving. For example, how much experience should be required before operating a self-driving vehicle? Should a special license be required? Should hands on wheel and foot on or near pedal be required and monitored? More research is needed to determine how much time it takes for drivers to react to emergency situations. A 1- or 2-second warning may not be enough time.

WHAT HAPPENS NEXT WITH THIS PROJECT?

We would like to continue validating these findings with more participants and different driving scenarios.

BIOMECHANICS IN AUTONOMOUS VEHICLES: A PILOT STUDY TO EXPLORE RESPONSES OF PEDIATRIC OCCUPANTS IN NON-TRADITIONAL SEATING CONDITIONS

Student Investigator:
Jalaj Maheshwari, MS, Children's Hospital of Philadelphia

Co-Investigator:
Aditya Belwadi, PhD, Children's Hospital of Philadelphia

IAB Mentors:
Jerry Wang, Humanetics Innovative Solutions Inc.; **Jason Stammen**, National Highway Traffic Safety Administration; **Mark Neal**, General Motors Holdings LLC; **Suzanne Johansson**, General Motors Holdings LLC; **Russ Davidson,** Lear Corporation; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Highly automated vehicle (HAV) technology is advancing rapidly with the promise of reducing injuries and deaths caused by motor vehicle crashes. A future vehicle with complete autonomy and minimal human intervention could allow drivers to engage in other activities, such as working, reading, or conversing with others in the vehicle. This sounds great, but what happens when these HAVs are involved in a crash or near-crash? We still need systems that protect occupants should a crash or swerve occur.

With this project we analyzed how crashes with HAV seating scenarios could impact the pediatric occupant. Since proposed HAV seating concepts have swiveling and reclining seat structures, we used computational modeling to explore two swiveled and reclined seating conditions in frontal crashes. A frontal impact in a traditional seat becomes a rear impact for the occupant that is swiveled around.

We used the PIPER six-year-old human model as the pediatric occupant model. The Position and Personalize Advanced Human Body Models for Injury Prediction (PIPER) were developed by the PIPER EU Consortium. The child model is scalable through a dedicated module within the PIPER application and has been extensively validated with experimental data from scientific literature.

WHY DID YOU FOCUS ON THIS ISSUE?

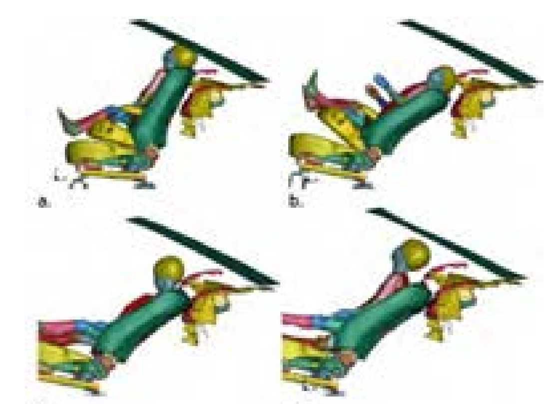
The invention of HAVs brings new challenges to researchers. As an engineer, I wanted to meet the challenge of helping auto manufacturers design safety systems and vehicles that can protect occupants inside HAVs.

WHAT DID YOU FIND?

After testing the swiveling condition with two different recline angles for a traditional low-back booster seat, we found that across all rearward facing frontal impact simulations (i.e., front passenger vehicle seat swiveled around to face rearward), the child rides along the seat recline during the impact. This causes an asymmetrical rotation of the child's torso about the 3-point lap-shoulder belt. These kinematics should be explored further to understand their implications.

WHAT'S NEXT?

The qualitative assessment of the kinematics in the crashes studied in this pilot study pave the way to conduct additional research in HAV crash scenarios to provide optimal protection to occupants. After studying the impact of a HAV crash on a single pediatric occupant in two seating configurations, moving forward we believe it is important to simulate more conditions, more seating positions, and more recline angles, as well as more occupants inside the vehicle, to provide the foundation for optimal safety in crash scenarios that might come with HAVs.



The images at the bottom show the motion of the child while restrained by a seat belt in a 48-degree recline case in a no-CRS condition, with the child undergoing (c) neck flexion first followed by (d) neck extenstion.

EFFECTIVENESS OF BOOSTERS VS. FORWARD-FACING FIVE-POINT HARNESS RESTRAINTS

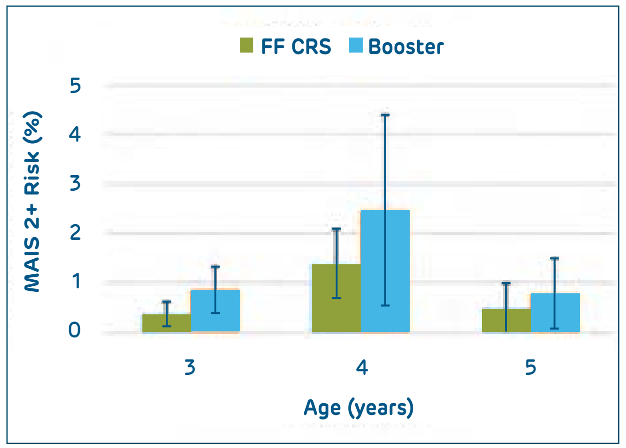
Principal Investigator:
Julie Mansfield, PhD, The Ohio State University

Co-Principal Investigator:
John H. Bolte IV, PhD, The Ohio State University

Project Team Member:
Rakshit Ramachandra, PhD, The Ohio State University

Student:
Li Li, The Ohio State University

IAB Mentors:
Emily Thomas, Consumer Reports; **Suzanne Johansson**, General Motors Holdings LLC; **Mark LaPlante**, Graco Children's Products Inc.; **Nick Rydberg**, Minnesota HealthSolutions; **Jason Stammen**, National Highway Traffic Safety Administration; **Julie Kleinert**, Technical Advisor; **Uwe Meissner**, Technical Advisor



Risk of Maximum Abbreviated Injury Scale (MAIS) 2+ injury was not significantly different between forward-facing CRS occupants compared to booster seat occupants for children in the age range of interest (roughly 3 to 8 years old). Sample sizes of injured children were small, especially for older FF CRS occupants.

WHAT WAS THE PURPOSE OF THIS PROJECT?

Best practice recommendations for CRS are partly determined by studying injury outcomes using federally available crash databases. While these sources have been studied for rear-facing versus forward-facing (FF) CRS, the literature is lacking information for the transition from a FF CRS to a belt-positioning booster (BPB) seat. This is a gap that crash testing cannot easily fill, as ATDs restrained in these two restraint types may not be able to discriminate these nuanced differences. This project's aim was to analyze this crucial transition point to ascertain if there are age, height, or weight milestones that might indicate the safest time to move from a FF CRS to a BPB.

We looked at injury outcome data for children near the FF CRS to BPB transition size. Data were analyzed from the two systems within the National Automotive Sampling System (NASS) – the General Estimates System (GES), which pulls from police reports, and the Crashworthiness Data System (CDS), which contains detailed data on a sample of crashes.

WHAT DID YOU FIND?

We found that, as expected, younger and smaller children tended to be seated in FF CRS, while older and larger children tended to be restrained in BPB. The overall risk of a child receiving a moderate to severe injury was typically less than 2 or 3 percent in both restraint types.

Due to limitations with the data, including the number of cases and level of detail across both sub-sets of the NASS database, we were not able to determine with statistical certainty if there is a safety benefit of a child of this age and size using one type of restraint over another.

WHAT ARE THE IMPLICATIONS FOR THESE FINDINGS?

The results of this study, which looked at the most recent federal data available, suggest that other sources are needed to answer the research question with certainty. Both types of restraints appear to work well since the risk of injury was low for both. Best practice guidelines currently recommend using FF CRS for as long as possible because children have less freedom of movement to wiggle out of the ideal position in this type of CRS.

EFFECTS OF ADJACENT SEAT POSITIONS ON CRS PERFORMANCE IN SIDE IMPACTS

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

Today's vehicle fleet features increasingly adaptable vehicle interiors, particularly in family vehicles. The CChIPS IAB was interested in investigating how CRS interact with the adjacent vehicle seat and if the position of the vehicle seat has an impact on CRS performance in a crash.

Dynamic side impact sled tests were conducted to define the performance outcomes of rear-facing (RF) and forward-facing (FF) CRS and belt-positioning boosters (BPB) in these conditions. Using vehicle seats from an IAB member company, a CRS or BPB was installed in either the outboard or center position with the adjacent seat either upright, folded, or removed. We analyzed the resulting kinematics, or movement, of the child seat and the ATD.

WHAT DID YOU FIND?

The outboard vehicle seat tended to better support the child restraints in terms of the width and lateral movement of CRS. When CRS were installed in the narrower center position, there was overhang of the CRS relative to the vehicle seat that impacted testing performance; those CRS moved farther to the side and off the vehicle seat cushion. We found substantial movement in the BPB, in particular. However, we also found that adjacent upright vehicle seats helped to control the motion of the CRS bases.

The 6-year-old Hybrid III ATD in a high back booster is installed on a narrow center seat position and exposed to a side impact when the adjacent outboard seat is removed (left) and in its standard upright position (right).

Our results provide additional evidence to support use of the top tether for a FF CRS; the tether helped to stabilize the child restraint, which is particularly important in a condition where the side of the CRS isn't fully supported by the vehicle seat.

WAS ANYTHING SURPRISING?

One thing that surprised us was just how far the CRS moves laterally during a crash. We observed evidence of lower anchor deformation when the RF CRS was installed on a narrow center seat with no adjacent seat to limit the downward movement of the CRS. That is an important design concept for vehicle manufacturers and CRS manufacturers to keep in mind — to ensure that the hardware can accommodate those lateral motions.

WHAT'S NEXT?

Based on the findings of this study, a 2019-2020 CChIPS project will investigate LATCH vs. non-LATCH installations for BPBs in impacts.

IN-DEPTH ANALYSIS OF CRASH CAUSATION FACTORS USING SHRP 2 (YEAR 1): REAR-END STRIKING CRASHES

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WHAT WAS THE PURPOSE OF THIS PROJECT?

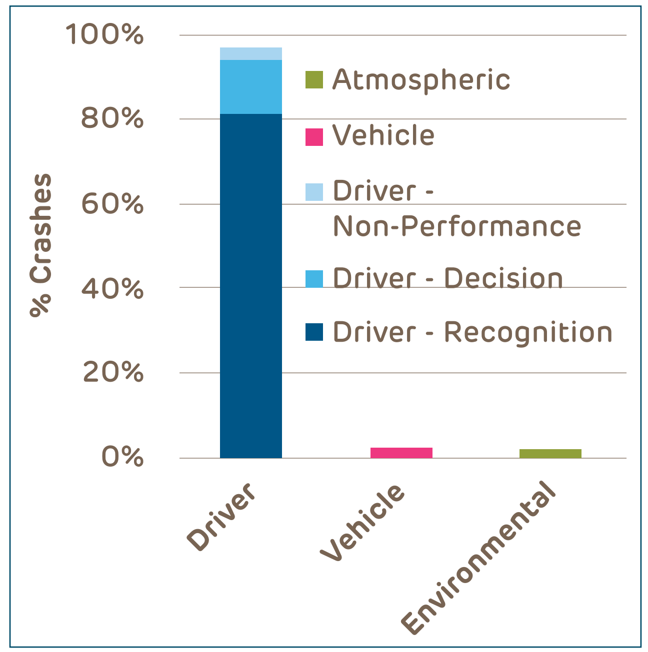
Most vehicles today are incorporating crash avoidance technology based on standards for all drivers, but we know that young drivers and older drivers are more likely to crash. To help improve or optimize these technologies for the types of crashes and errors these drivers are making, we used the Strategic Highway Research Program (SHRP2), a large naturalistic driving study that recorded information from vehicles driven over two years, to study the specific errors made and other factors leading up to rear-end crashes, the most common type of crash. By studying this video footage, we know exactly what led to each crash instead of relying on personal stories that can be inaccurate.

WERE ANY OF THE RESULTS SURPRISING?

The wide range of distractions inside the car leading up to the crash was surprising. While cell phone use was a big one, we also saw drivers fall asleep, eat, and apply makeup. Even with a single specific type of crash, there's a range of reasons leading up to it and a range of technologies that could help prevent it.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

Our industry sponsors found the results valuable because we provided real-world crash information instead of information from test track or simulated crashes, which tend to be conducted in more idealized conditions. With these data, they can adapt their simulations or test procedures to match these real-world situations to design crash avoidance technologies that specifically address why younger and older drivers crash.



This chart shows critical causation factors for 93 SHRP2 rear-end striking crashes. Driver error was the most common contributing factor, accounting for 96 percent of all critical contributing factors.

WHAT'S NEXT FOR THIS LINE OF RESEARCH?

In Year 2, we will focus on other types of crashes: road departures; intersections; pedestrians and cyclists; sideswipes; head-ons; and animal crashes. Once we understand the factors that lead to these types of crashes, we can make recommendations to address them with various Advanced Driver Assistance Systems or other interventions.

ENSURING SAFETY OF CHILDREN IN SELF-DRIVING VEHICLES

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WHAT WAS THE PURPOSE OF THIS PROJECT?

We wanted to prepare for a world where children may ride unaccompanied in autonomous vehicles to get to school or soccer practice or in emergency situations. We conducted an exploratory study involving 19 parents of 8- to 16-year-olds where they took rides in our driving simulator in both manual and autonomous modes. Then, some of their children rode alone in the back seat of the simulator in autonomous mode. We then interviewed them about their rides and their perceptions about autonomous cars.

WHAT DID YOU FIND AND WERE ANY RESULTS SURPRISING?

Over 60 percent of parents said they would be comfortable riding in an autonomous car either alone or with their child; but, only about 20 percent would be comfortable with their child riding alone in one. What was most surprising: Parents want a safe haven in case the vehicle can't get to the pre-programmed destination, such as a police station or public library. As a society, we will have to figure out how to provide this infrastructure for both unaccompanied children and passengers with disabilities.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

Our results can be used to guide additional research efforts to inform autonomous vehicle design. For example, children want speech-based interaction, and parents want communication from autonomous vehicles to keep them informed when their children are riding unaccompanied, such as an alarm if a child is not buckled up and a notification when the child arrives at the destination.

WHAT'S NEXT FOR THIS LINE OF RESEARCH?

We would like to develop a vocabulary of spoken commands and queries that children could be trained to use when communicating with autonomous vehicles. In addition, we would like to develop passenger training for safe use of autonomous vehicles.

Feedback From Parents

Solo child	Stay home	Ride alone in a bus or train	Ride alone in a taxi	Ride alone in a self-driving car
Range of Ages	8 – 13 years	12 – 16 years	10 – 13 years	8 – 18 years
Most Frequently Cited Age	11 years	13 years	13 years	16 years

Each parent focus group started with a discussion about the minimum age at which a parent would allow a child to stay home alone, followed by the minimum age that they would allow a child to use different forms of transportation without a chaperone.

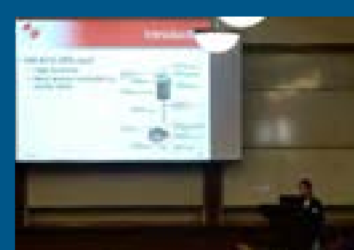
PREPARING FUTURE INDUSTRY SCIENTISTS

Research Experiences for Undergraduates (REU)

The Center for Injury Research and Prevention (CIRP) at CHOP (the administrative home of CChIPS) hosts 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 minimal internship opportunities and no available doctorate program. In our seventh summer offering this program, we received over 340 applications for 12 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. Many of these students worked on CChIPS projects with CChIPS faculty. Several students also had the opportunity to shadow clinicians at CHOP, one of the nation's top children's hospitals.

The 2019 CIRP REU class following Student Research Day, where they presented the research they worked on over the summer. The students are joined by Training Manager Carol Murray, MSS (left), and Training Director Thomas Seacrist, MBE (right).

Injury Biomechanics Symposium



At left, CHOP/Penn's Colin Huber and Madeline Griffith (front row, first and second from left) are pictured with fellow oral presenters. At right, OSU's Reagan Di Iorio presents on CChIPS research.

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). In its 15th 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 2019, it hosted 120 attendees, including 30 student presenters from 13 universities, including five international universities. CChIPS student researchers were well-represented at the conference. Among the presenters were Madeline Griffith, a master's student at CHOP/Penn who presented on the "Can the Startle Reflex be Manipulated to Reduce Take-over Time in Pre-crash Scenarios for Autonomous Driving?" project (*see project summary on Page 9*) and Reagan Di Iorio, an undergraduate student at OSU who presented on the "Sensitivity Analysis on Factors that Influence Head Responses of the Hybrid III 6-Year-Old ATD" project (*see project summary on Page 10*). CHOP and OSU were also represented by students presenting high-quality biomechanics work outside of CChIPS. They included Colin Huber, a PhD student at CHOP/Penn; Angela Tesny, a PhD student at OSU; Vikram Pradhan, a PhD student at OSU; and Akshara Sreedhar, a master's student at OSU.

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

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.

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