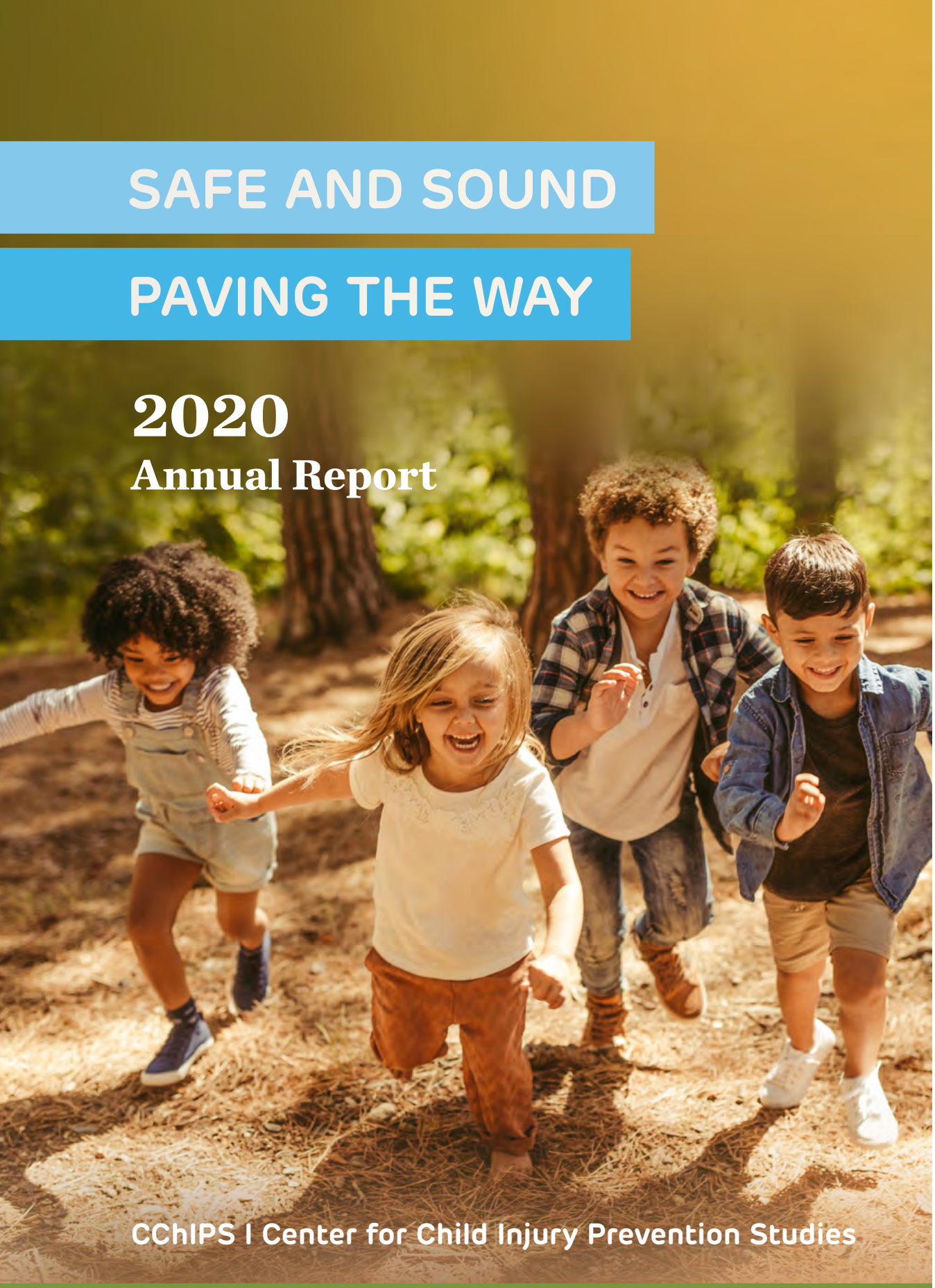
SAFE AND SOUND

PAVING THE WAY

2020
Annual Report



CChIPS | 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 2019-2020 Project Year!

The Center for Child Injury Prevention Studies (CChIPS) takes a unique approach to child safety research. For 15 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

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 14 member organizations from industry, advocacy, and government agencies.

In 2019-2020, the IAB funded eight research projects across the Center's five-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 designed to reach 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 nearly half a million page views in calendar year 2019.

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 – such as autonomous vehicle technology and its impact on child safety – as guided by science and our IAB member companies. We are proud to be a driving force behind innovative research that continues to push the envelope in working to improve child and adolescent safety.

2020 marks an exciting transition: At the end of this fiscal year, CChIPS will receive the distinguished designation as a graduated NSF Industry-University Cooperative Research Center (IUCRC). We thank NSF for the generous support that we have received since 2005. With this support, we established processes and a structure that produced over 160 child safety projects and provided mentorship to hundreds of undergraduate and graduate students working on those projects. In addition, CChIPS research has been published in peer-reviewed journals and presented at academic conferences throughout the US and the world. Our foundation is now strong and at the end of this year, we will be independent of the NSF support. We look forward to continuing to partner with our IAB member companies to advance the CChIPS mission of conducting high-impact child safety research.

Another exciting announcement is the promotion of Julie Mansfield, PhD to the CChIPS leadership team. Dr. Mansfield, a research assistant professor who has worked on CChIPS projects since 2009, will now lead the CChIPS research site at OSU. Dr. Bolte will continue to be actively involved with CChIPS projects, and we are grateful for his leadership and ongoing support.

Julie Mansfield, PhD, joins the CChIPS leadership team.

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

britax♦ · Calspan · CR Consumer Reports · Federal Aviation Administration

FCA Fiat Chrysler Automobiles · GM · Graco · Honda The Power of Dreams

Humanetics Innovative Solutions · Lear Corporation · MinnHealth Minnesota HealthSolutions Corporation

NHTSA · Toyota · UPPAbaby

♦ Founding IAB Member Company

CChIPS Mission Statement

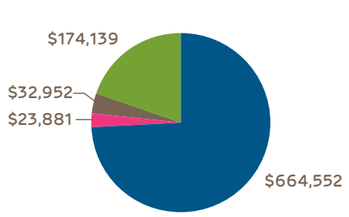
The Center for Child Injury Prevention Studies (CChIPS) is advancing the safety of children, youth, and young adults by facilitating scientific inquiry into childhood and young adult injuries and translating these findings into commercial applications and educational programs for preventing future injuries.

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. For the 2019-2020 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 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.

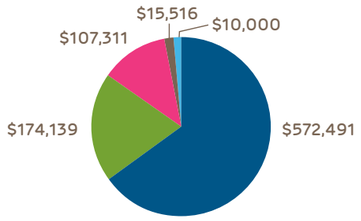
REVENUE FOR 2020



Total Revenue: $895,524

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

EXPENDITURES FOR 2020



Total Expenditures: $879,457

- 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

14 Members

$664,552 in research funds
excluding supplemental funds

The research pool funded 11 projects in 2019-2020, 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
8 Projects	5 Projects	4 Projects	5 Projects	4 Projects
$727,821*	$433,041*	$283,520*	$373,259*	$373,730*

What Does the CChIPS ROI Look Like for One Member?

In 2019-2020, a large business with an interest in child restraint design and performance contributed $65,000 for access to research valued at $727,821.

*** 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:

2019-2020 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. Additional project information is included 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 and 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

CHARACTERISTICS OF CRASHES REPRESENTED BY THE FMVSS 213 CRASH PULSE

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

Co-Investigators:
Kristy Arbogast, PhD, Children's Hospital of Philadelphia;
Matthew Maltese, PhD, University of Pennsylvania;
Kristi Metzger, PhD, Children's Hospital of Philadelphia;
Thomas Seacrist, MBE, Children's Hospital of Philadelphia

Student:
Shreyas Sarfare, University of Pennsylvania

IAB Mentors:
Allison Schmidt, Britax Child Safety Inc.; **Jonathan Gondek,** Calspan Corporation; **Mike Kulig,** Calspan Corporation; **Emily Thomas,** Consumer Reports; **Mark LaPlante,** Graco Children's Products Inc.; **Guy Nusholtz,** FCA US LLC; **Suzanne Johansson,** General Motors Holdings LLC; **Jerry Wang,** Humanetics Innovative Solutions Inc.; **Russ Davidson,** Lear Corporation; **Uwe Meissner,** Technical Advisor

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

The federal regulation in the US for testing child restraints, FMVSS 213, utilizes a crash pulse representing a Delta-V (change in velocity) of 30 mph. Prior research published in 1998 suggested this crash pulse is within the range of frontal crashes that can result in serious or fatal injury, based on the Abbreviated Injury Scale (AIS). However, the data for this research are somewhat outdated and limited: The data source was the federal National Automotive Sampling System – Crashworthiness Data System (NASS-CDS) from the early 1990's that only included front seat occupants. Rear seat occupants, including most child occupants, were not included.

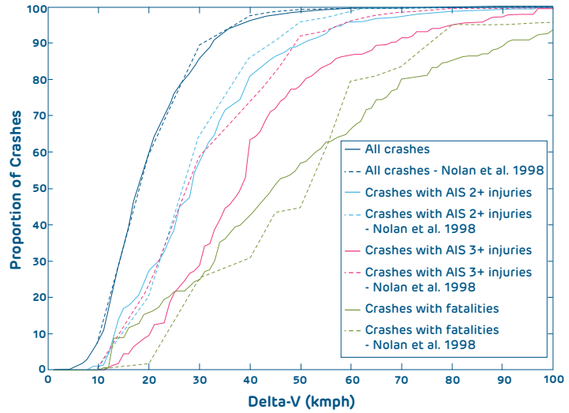
To update these analyses, our project aims were two-fold: 1) use more current data to establish the updated relationship between Delta-V and injury severity for occupants of all ages; 2) compare crash pulse characteristics – peak, duration, shape, etc. – between regulatory test pulses (FMVSS 213, the European standard: ECE R44, and the pulse used by Consumer Reports for its vehicle crash tests) and full-scale vehicle crash tests matched to NASS-CDS data. We utilized the most recent five years of available NASS-CDS data (2010-2015) and extracted crash, vehicle, and occupant data for frontal crashes.

WHAT WERE THE FINDINGS?

For Aim 1, we found that when compared to the 1998 analyses, our more current analysis determined that a lower proportion of crashes with AIS 2+ and AIS 3+ injuries occurred at the same Delta-V. We attributed this result to advances in passive safety, restraints, and in-vehicle technology in the more modern time frame we studied. For Aim 2, we found that the three regulatory crash pulses are generally within the boundaries of the full-scale vehicle crash tests matched to the most recent NASS-CDS data. However, we did identify some specific differences in pulse characteristics, such as maximum deceleration, onset rate, Delta-V, and time of deceleration, that might need to be re-visited in the future.

WHAT ARE THE IMPLICATIONS FOR INDUSTRY?

Our study provides evidence for vehicle manufacturers that advanced vehicle technology is effective at preventing serious injury. For future work, this project on frontal crashes points to the need to conduct similar analyses that inform regulatory pulses for lateral or oblique crashes.



This graph compares the Delta-V distribution of frontal crashes from the most recent five years (2010-2015) of NASS-CDS (solid lines) and the Delta-V distribution of crashes from NASS 1990-1995 (Nolan et al 1998, dashed lines).

QUANTITATIVE CHARACTERIZATION OF AEB PULSES ACROSS THE MODERN FLEET: INSIGHTS ON THE RELATIONSHIP BETWEEN AEB PULSE CHARACTERISTICS AND OCCUPANT SAFETY

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

Co-Investigator:
Thomas Seacrist, MBE, Children's Hospital of Philadelphia

Students:
Madeline Griffith, University of Pennsylvania;
Mikayla Schneider, University of Notre Dame

IAB Mentors:
Shawn Sinclair, Consumer Reports; **Yi Glaser,** General Motors Holdings LLC; **Mark LaPlante,** Graco Children's Products Inc.; **Jerry Wang,** Humanetics Innovative Solutions Inc.; **Jason Stammen,** National Highway Traffic Safety Administration; **Jason Hallman,** Toyota USA; **Schuyler St. Lawrence,** Toyota USA; **Uwe Meissner,** Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

An increasing number of vehicles on today's roadways have automatic emergency braking (AEB). Federal testing criteria are mainly based on the vehicle's successful speed reduction to avoid collision with an obstacle. Therefore, AEB pulses can vary between vehicles and manufacturers; accordingly, occupants' motion when exposed to these different pulses also varies. This project aimed to quantify important pulse characteristics for each AEB system and use that information to categorize pulses for future testing.

HOW WAS THE RESEARCH CONDUCTED?

We extracted publicly available information on 2,279 AEB tests from a range of vehicles from the Insurance Institute for Highway Safety test database. We identified tests in which the vehicle contacted the target (613) and had no contact (1,666). Utilizing machine learning principles – a relatively novel technique now used in autonomous driving research – we identified categories of pulses from a range of pulse characteristics, including deceleration magnitude, speed reduction, ramp time, and duration of the deceleration phase.

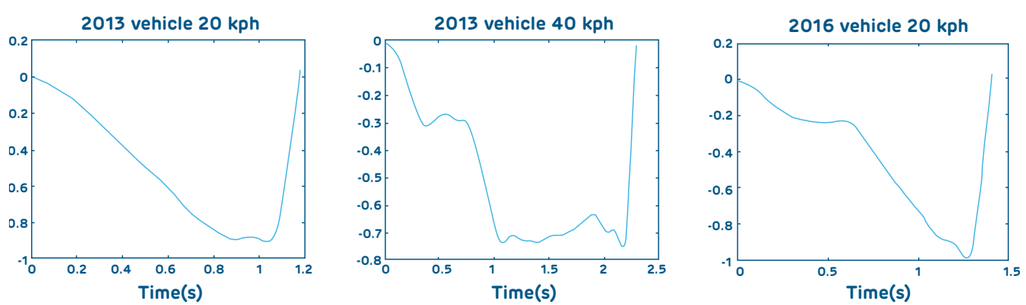
WHAT WERE THE FINDINGS?

The categorizations of the AEB pulses show few differences between pulses: When all AEB pulses (contact and no contact) were considered for the machine learning cluster analysis, only three clusters were identified. However, those three clusters show statistically significant differences between their pulse characteristics, such as ramp-time, jerk, and maximum deceleration, suggesting categorical grouping of pulses can be achieved.

Additionally, we found that contact between the vehicle and the target decreased dramatically in more recent model vehicles. In AEB tests from 2013, 60% showed contact between the vehicle and the target. In 2019 tests, only 1.7% of vehicles contacted the target. This indicates that AEB technology has improved significantly through the years, so much so that the likelihood of contact between the vehicle and the target is low when AEB is present.

WHAT ARE THE IMPLICATIONS FOR INDUSTRY AND WHAT'S NEXT?

While there was a significant decrease in contact during testing when AEB was present in more recent model year vehicles, it is unclear how or if occupant motion is affected by the differences in AEB pulses. Because that determination can only be made via laboratory testing, an important next step in developing AEB systems and standards should be to examine not only the efficacy of the AEB, but also the way the braking is achieved to improve occupant safety, particularly for children.



These graphs show examples of AEB pulses with different shapes. At left: a pulse with a shorter steady-state (maintained maximum acceleration) phase; at middle: a pulse with a longer steady-state phase; at right: a pulse with only a maximum acceleration point and no steady-state.

A NATURALISTIC SEATING STUDY OF CHILDREN IN BOOSTER SEATS WITH THE PIPER HUMAN BODY MODEL; FRONTAL AND OBLIQUE IMPACTS IN THE VEHICLE ENVIRONMENT WITH SCAB AND AEB

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

Co-Investigator:
Aditya Belwadi, PhD, Children's Hospital of Philadelphia (current affiliation: Tesla, Inc.)

Students:
Clayton Falciani, Drexel University;
Shreyas Sarfare, University of Pennsylvania

IAB Mentors:
Robert Branam, American Honda Motor Co., Inc.; **Farid Bendjellal,** Britax Child Safety Inc.; **Emily Thomas,** Consumer Reports; **Suzanne Johansson,** General Motors Holdings LLC; **Mark LaPlante,** Graco Children's Products Inc.; **Arjun Yetukuri,** Lear Corporation; **Jason Stammen,** National Highway Traffic Safety Administration; **Paul Gaudreau,** UPPAbaby; **Julie Kleinert,** Technical Advisor; **Uwe Meissner,** Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Traditionally, when evaluating CRS performance, ATDs are seated centrally and upright for testing. However, real-world evidence suggests that children move about in child restraints, making the optimal upright posture less likely in the real world. We wanted to understand the differences in injury outcomes between the optimal and actual postures of child occupants in a crash impact with and without pre-crash automatic emergency braking (AEB).

Using computational modeling, we simulated four different naturalistic seating positions (leaning forward, leaning inboard, leaning outboard, and pre-submarining) along with the standard seating position using the 6- and 10-year-old PIPER human body models restrained in booster seats. We ran these tests with and without pre-crash AEB.

WHAT WERE THE FINDINGS?

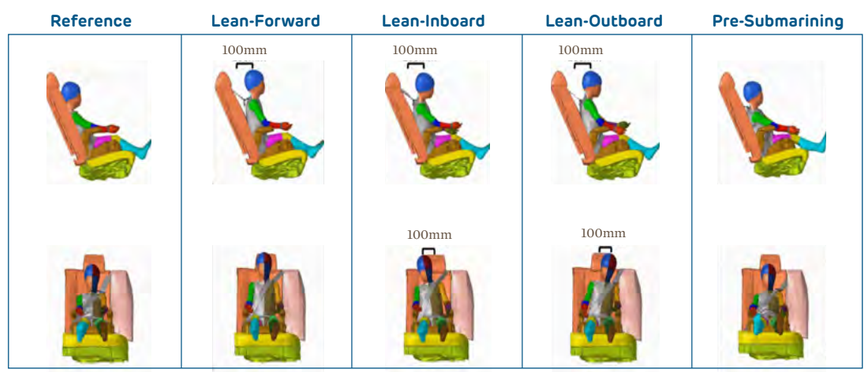
The injuries predicted by the models varied widely by age, seating position, and crash type. Overall, child occupants leaning inboard showed the greatest level of head excursion among the configurations as they moved out of the belt more easily. Further, when compared with no AEB, the injury metrics were lower for crashes with a pre-crash AEB, despite the same crash impact velocity.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

This work provides areas for future optimization and testing – in particular, examining how to improve safety for children in common naturalistic positions. Such insights are critical to the automotive, CRS, and individual component manufacturers, including vehicle seat manufacturers charged with safety design upgrades to better protect occupants from crash-related injuries that meet the needs of children in natural postures. Data from this project can also be used to guide government agencies and labs in testing conditions to better represent the real world.

WHAT'S NEXT?

We would like to explore these naturalistic seating postures using ATDs in actual crash tests to understand how they respond and to further study the injuries associated with the four seating postures in different types of booster seats. Additionally, this project only explored frontal impacts and frontal offset impacts. We would be interested in looking at other real-world impact scenarios, such as side impacts, to continue studying naturalistic seating injury outcomes.



Four naturalistic seating postures, plus the reference upright seating posture, for the 6-year-old occupant studied in this computational analysis.

EPIDEMIOLOGIC INVESTIGATION OF CHILD RESTRAINT INSTALLATION POSITION AND SERIOUS INJURY AMONG CHILDREN IN MOTOR VEHICLE CRASHES

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

Co-Investigators:
Allison Curry, PhD, MPH, Children's Hospital of Philadelphia;
Melissa Pfeiffer, MPH, Children's Hospital of Philadelphia

Student:
Leah Lombardi, Drexel University

IAB Mentors:
Allison Schmidt, Britax Child Safety Inc.; **Quentin Walsh,** Britax Child Safety Inc.; **Emily Thomas,** Consumer Reports; **Fariba Famili,** FCA US LLC; **Suzanne Johansson,** General Motors Holdings LLC; **Mark LaPlante,** Graco Children's Products Inc.; **Justin Robinson,** Graco Children's Products Inc.; **Jerry Wang,** Humanetics Innovative Solutions Inc.; **Mladen Humer,** Lear Corporation; **Nick Rydberg,** Minnesota HealthSolutions; **Julie Kleinert,** Technical Advisor; **Uwe Meissner,** Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Recommendations exist for children to ride in rear-facing CRS in motor vehicles. However, limited surveillance data is available regarding rear-facing (RF) versus forward-facing (FF) CRS orientation and injury outcomes among children in motor vehicle crashes (MVCs). Using the New Jersey Safety and Health Outcomes (NJ-SHO) Data Warehouse, we examined restraint use and injury outcomes among children ages 0-8.

This project was the first to use linked crash occupant data from the NJ-SHO, which provides a novel data source to examine questions regarding MVCs and injury. New Jersey recently updated its police crash report to include information on CRS orientation, providing detail that was historically absent from crash data. Further, the NJ-SHO contains hospital-reported injury data, permitting us to more rigorously examine injury outcomes.

WERE ANY OF THE RESULTS SURPRISING?

Despite recommendations from the American Academy of Pediatrics, car sear manufacturers, and NJ's 2015 mandate that children under age 2 utilize RF CRS, only 57% of crash-involved child occupants under age 2 were RF. When comparing children under age 2 in RF versus FF CRS, we observed similar proportions of children seeking post-crash hospital care. However, children in RF CRS were significantly less likely to be diagnosed with an injury than those restrained in a FF CRS. Our goal is to supplement these preliminary results with additional years of crash and hospital data to increase the number of child occupants in our study sample and further examine these findings.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

This project is our most recent effort to extend CChIPS' longstanding commitment and expertise in developing a sustainable MVC occupant injury data source focused specifically on children. This is a valuable resource for industry partners interested in better understanding CRS use and injury mitigation efforts.

Motor vehicle crash and hospital discharge data from the NJ-SHO Data Warehouse were used to examine child restraint use and injury outcomes.

WHAT'S NEXT?

One advantage of the NJ-SHO is the ongoing commitment to obtain recent years of data, permitting us to examine a larger number of crash-involved child occupants and trends in CRS use and injury over time. We are also identifying new research questions related to crash and vehicle characteristics as they relate to injury outcomes for children, as well as other occupants and drivers.

UNDERSTANDING CHILD RESTRAINT SYSTEM USE ON AIRPLANES

Principal Investigator:
Aimee Palumbo, PhD, MPH, Children's Hospital of Philadelphia

Co-Investigators:
Danielle Erkoboni, MD, Children's Hospital of Philadelphia;
Julie Mansfield, PhD, The Ohio State University

Student:
Vaibhavi Mone, Drexel University

IAB Mentors:
Joseph Pellettiere, Federal Aviation Administration; **Amanda Taylor,** Federal Aviation Administration; **Mark LaPlante,** Graco Children's Products Inc.

WHAT WAS THE PURPOSE OF THE PROJECT?

Although the FAA and the American Academy of Pediatrics recommend using a CRS on airplanes, little research had been conducted regarding CRS use in this setting to inform this guidance for parents. As a start, we wanted to learn about current CRS use by caregivers on planes and the reasons underlying why or why not they were using them.

HOW WAS THE STUDY CONDUCTED?

We surveyed 786 parents and caregivers who had recently traveled by air with a child age 5 or younger about their use or non-use of CRS and other factors that impact their travel experience. We also conducted focus groups with 16 airline personnel to understand their experiences interacting with families traveling with young children.

WHAT DID YOU FIND?

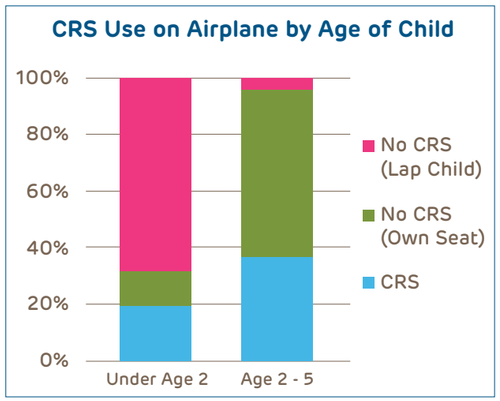
Nearly 40% of children under age 5 sat in their own seat without a CRS, 29% sat in their own seat with a CRS, and 32% were held in a caregiver's lap. Safety and ease of transporting (i.e., having a place to set the child during the flight and the need to have the CRS at their destination) were primary reasons for choosing to use a CRS. Cost and difficulty of logistics (i.e., carrying the CRS through the airport and installing it in the airplane seat) were cited most often for not using a CRS. Since these families viewed flying as safe, not using a CRS wasn't seen as an unsafe choice. The focus groups with airline personnel revealed that flight attendants believe that most families do not fully understand their role as trained safety professionals.

WERE ANY OF THE RESULTS SURPRISING?

Many caregivers found it more convenient to use the CRS on the airplane than to travel without it, while others cited specific difficulties with using the CRS. We would like to learn more about what makes the same experience positive or negative for families.

WHAT'S NEXT?

The overall goal is to prevent injury to children. Given how safe air travel is, it might be important to think of the whole trip – making the overall travel experience safer by considering the automobile transportation to and from the airport. Some considerations might include improving the availability of a CRS at their final destination, such as a rental car or ride share. Further, more should be done to encourage more families to fly rather than opt for road travel for long distances.



Age	CRS	No CRS (Own Seat)	No CRS (Lap Child)
Under 2	67	43	236
2 - 5	163	260	17

ATD RESPONSES IN REAR-FACING/FORWARD-FACING CONFIGURATIONS IN FRONTAL AND REAR IMPACT SLED TESTS

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

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

Project Team Members:
Kristy Arbogast, PhD, Children's Hospital of Philadelphia;
Aditya Belwadi, PhD, Children's Hospital of Philadelphia (current affiliation: Tesla, Inc.)

IAB Mentors:
Farid Bendjellal, Britax Child Safety Inc.; **Mark Pitcher,** Britax Child Safety Inc.; **Allison Schmidt,** Britax Child Safety Inc.; **Jonathan Gondek,** Calspan Corporation; **Mike Kulig,** Calspan Corporation; **Mark LaPlante,** Graco Children's Products Inc.; **Jason Stammen,** National Highway Traffic Safety Administration; **Uwe Meissner,** Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

Some European rear-facing CRS can accommodate larger children up to age 6 years. These child restraints have support legs, also known as load legs, to reduce rotation during frontal impacts, and some have lower tethers to reduce rotation during rear impacts.

Our aims for this project were two-fold: 1) to investigate the effects of these anti-rotation devices during sled tests, and 2) to compare a convertible CRS in forward-facing (FF) and rear-facing (RF) configurations during frontal and rear impacts. This project builds upon prior CChIPS work led by Dr. Aditya Belwadi, which investigated the effect of load legs in infant seats using a 12-month-old and an 18-month-old ATD in frontal impacts.

HOW WAS THE RESEARCH CONDUCTED?

We used sled testing to investigate the performance of three exemplar CRS models: one RF infant CRS with flexible lower anchors (LATCH) and a support leg, one RF infant CRS with rigid lower anchors (ISOFIX) and a support leg, and one extended-use convertible CRS attached via a seat belt with a retractable support leg and lower tethers.

We tested a variety of different scenarios. The two RF CRS were tested with 12- and 18-month-old ATDs, with and without load legs in frontal impacts. The convertible seat was tested with 3- and 6-year-old ATDs in frontal and rear impacts – in frontal impacts the seat was tested FF and RF, with and without load legs, and in rear impacts the seat was tested FF and RF, with and without lower tethers.

WHAT WERE THE FINDINGS?

We found a safety benefit – reductions in head injury metrics and non-injurious levels of neck injury metrics – associated with the support leg in frontal impacts across all ATDs and RF CRS models. For the convertible CRS, the lower tethers reduced rotation of the CRS during rear impacts. While previous research had similar findings for the 3-year-old ATD, we were able to demonstrate that those safety benefits can extend up to 6 years old.

For the extended-use convertible CRS, we found elevated neck injury metrics for FF child occupants and elevated head injury metrics for the RF CRS in the frontal impacts. The elevations in head injury metrics for RF occupants in frontal impacts were attributed to interactions with the blocker plate, intended to represent the front seat in a vehicle. These interactions need to be further investigated in tests using an actual vehicle seat to accurately represent the dynamic response of the front seat back.

WHAT ARE THE IMPLICATIONS FOR INDUSTRY?

This study provides valuable information to CRS manufacturers regarding the design and development of anti-rotation devices, such as support legs and lower tethers, and also supplements epidemiologic studies regarding child seat policy.

The 12-month-old CRABI ATD is tested in a RF CRS with LATCH and a load leg during a frontal impact. There was no head contact with the blocker plate.

IN-DEPTH ANALYSIS OF CRASH CAUSATION FACTORS USING SHRP2 (YEAR 2): ROAD DEPARTURES, INTERSECTIONS, AND VULNERABLE ROAD USERS

Principal Investigator:
Thomas Seacrist, MBE, Children's Hospital of Philadelphia

Co-Investigators:
Helen Loeb, PhD, Children's Hospital of Philadelphia;
Jalaj Maheshwari, MS, Children's Hospital of Philadelphia

Project Team Member:
Kevin Heller, BA, Children's Hospital of Philadelphia

Students: **Gregory Chingas,** Drexel University; **Shreyas Sarfare,** University of Pennsylvania; **Maya Thirkill,** Spelman College

IAB Mentors: **Charles Thomas,** American Honda Motor Co., Inc.; **Kelly Funkhouser,** Consumer Reports; **Fariba Familia,** FCA US LLC; **Guy Nuscholz,** FCA US LLC; **Dan Glaser,** General Motors Holdings LLC; **Rini Sherony,** Toyota USA; **Schuyler St. Lawrence,** Toyota USA; **Uwe Meissner,** Technical Advisor

WHAT WAS THE PURPOSE OF THIS PROJECT?

This project was a necessary extension of Year 1 where we took a deep dive into the Strategic Highway Research Program (SHRP2) naturalistic database to look at what causes rear-end crashes. In Year 2, we focused on other types of crashes: road departures; intersections; impacts with pedestrians and cyclists; sideswipes; head-ons; and animal crashes. Then, working with our industry partners, we examined specific causes of crashes and what advanced driver assistance systems (ADAS) technologies and engineering improvements could be used or improved to prevent them from occurring for those most at-risk: teen, young adult, and older drivers.

WHAT DID YOU FIND?

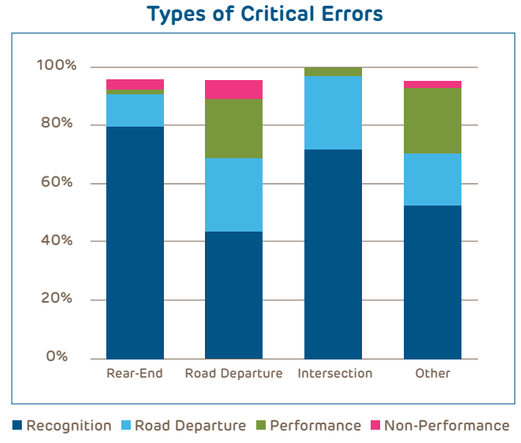
Recognition errors were most common in all of the crash types, which were due to cell phone use and other distractions, but decision errors occurred more often in crashes at intersections. We also didn't find any gender differences. The use of ADAS features, such as automatic emergency braking and vehicle-to-vehicle technology, have great potential to address these driving errors.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

This highly collaborative project brought together industry experts on technology and research experts on driving science. Together, we learned what specifically caused these crashes and how certain ADAS technologies can potentially be used to address these crash factors. Our findings can also be used to develop more robust vehicle test procedures, thus decreasing overall crash risk.

WHAT'S NEXT FOR THIS LINE OF RESEARCH?

We want to determine the type, frequency, and associated characteristics of crash scenarios autonomous vehicles (AVs) will encounter when interacting with human drivers. Although AVs will be capable of identifying hazards and safely navigating our roadways, how will they handle driving errors committed by humans? Using SHRP2, we want to highlight these potential scenarios so that AV technologies can be developed to avoid these crash scenarios.



This chart shows critical errors committed for 246 SHRP2 crashes across crash type. "Other" includes pedestrians and cyclists, sideswipes, head-ons, and animal crashes

HOW DO NOVEL SEAT POSITIONS IMPACT USABILITY OF CHILD RESTRAINTS?

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WHAT WAS THE PURPOSE OF THIS PROJECT?

Autonomous vehicles (AVs) are being tested, and vehicles with varying levels of autonomy are already on our roads today. AVs raise a host of safety questions about child passengers, including how families with children that require CRS would be impacted by non-traditional seating arrangements that are proposed for AVs. In this project, we created a simulated AV interior to explore how three different "living room style" seating arrangements would affect the ability of parents to install and remove CRS, families' comfort level, and how well children were restrained.

We recruited 14 families with children ages 0 to 7 to experience three simulated seating configurations: Front-Facing-In, Sides-Facing-In, and X (all seats at oblique angles relative to the front windshield). Families installed CRS in the different configurations and then sat and interacted with their children for a period of time. When they were finished, we asked both the parents and children questions about what they liked and didn't like about each configuration.

WHAT DID YOU FIND?

The majority of families preferred the X seating arrangement where everyone is facing each other on a diagonal. They liked being able to face and interact with each other, their ability to see the road, and the level of legroom. No one wanted to sit rearward facing. Time to install and remove CRS were similar for all three seating arrangements.

WERE ANY OF THE RESULTS SURPRISING?

Families found the X seating arrangement enabled them to more easily install and remove the CRS because it featured the most space adjacent to the side door (see photo at right). This indicates that AV designers may want to consider the position of the doors relative to the seats and how families enter and exit when developing seating configurations.

WHAT ARE THE INDUSTRY IMPLICATIONS FOR THIS RESEARCH?

AV manufacturers have the opportunity to consider family use while these vehicles are still in the concept, design and early prototyping stages. We don't want child safety to be an afterthought. More research is also needed to understand how alternative seating arrangements affect the forces experienced by all passengers during crashes, including children.

Seating fixture with seats arranged in an 'X' configuration. Front seats are rotated 135° from their usual position and rear seats are rotated 45° from their usual position. Right seats are rotated to the left and left seats are rotated to the right. All seats directly face the seat diagonally opposite itself.

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-supported Injury Science REU site, 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 eighth summer offering this program, we received over 590 applications for 12 REU internship positions for Summer 2020. In the wake of COVID-19 when in-person training was suspended, the CIRP Training team quickly developed an innovative virtual REU program that offered 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. While the 10-week REU program concluded in August, several students elected to continue on at CIRP, working on research projects remotely into the fall.

Student Spotlight: Niky Zaragoza-Rivera, PhD

Niky Zaragoza-Rivera with OSU's mascot, Brutus, at a Buckle Up With Brutus car seat check event.

Yadetsie (Niky) Zaragoza-Rivera has incorporated her passion for child safety into her graduate and doctoral programs through her work with OSU's Injury Biomechanics Research Center (IBRC). Shortly after arriving at OSU in 2015 for her PhD program, an early conversation with current CChIPS co-director and IBRC faculty member Dr. Julie Mansfield sparked Niky's interest in becoming involved with CChIPS research projects.

Niky began her work with CChIPS assisting with motion tracking of ATD and CRS kinematics in sled testing and soon moved to analyzing data related to a prior CChIPS project on pediatric ankle stiffness. Through the latter project, she received the opportunity to work on the 2016-2017 CChIPS project "Lateral Cervical Spine Stiffness in Children," led by Dr. Laura Boucher, where her contributions included working with the team to develop and validate a custom head fixture. This project became Niky's PhD dissertation study.

In addition to her CChIPS work, Niky has been integral to OSU's Buckle Up With Brutus (BUWB) initiative, which provides education and resources to families around child passenger safety. As a certified Child Passenger Safety Technician assisting caregivers one-on-one, Niky saw the language barrier faced by Spanish-speaking caregivers. That experience, coupled with her interest in American Sign Language (ASL), led her to spearhead efforts to increase accessibility to child seat education materials for Deaf caregivers, including a YouTube channel that features the "ASL Series." To further the team's goal of making science accessible to everyone, Niky and her colleagues have revamped the BUWB social media presence, including creating infographics that make research conducted within BUWB and CChIPS more accessible to the general public.

Niky completed her PhD in Biomedical Engineering with a focus on Biomechanics at OSU in Spring 2020. As she begins her professional career as a Biomechanical Consultant, she wants to help bridge the gap of safety advancements and advocacy for children and promote the development of pediatric-specific analyses and protections. "As my career grows," she says, "my hope is to be able to tie in children to all facets of safety, protection, and advocacy."

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.

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