Safe and Sound

The Center for Child Injury Prevention Studies
2012 Annual Report

Center for Child Injury Prevention Studies
The Children's Hospital *of* Philadelphia®
RESEARCH INSTITUTE
Wexner Medical Center

Partnering for Safety

A MESSAGE FROM OUR DIRECTORS

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

Safe and sound. That's what parents hope for and our Center works toward. In fact, the future is bright as we continue to advance child safety through evidence to inform action. The Center for Child Injury Prevention Studies (CChIPS) at The Children's Hospital of Philadelphia Research Institute is proud of its achievements in 2012. Through a unique partnership with our Industry Advisory Board (IAB), now with 20 members, our researchers are pinpointing and assessing the causes of injuries to children and young adults. With this knowledge, we can prevent injuries and engineer solutions that save children's lives. On behalf of the IAB and our dedicated team of researchers, we are excited to share research highlights and summary updates from CChIPS' past year in this annual report:

Founded in March 2005 with a grant from the National Science Foundation (NSF), CChIPS is one of over 60 Industry/University Cooperative Research Centers (I/UCRC) funded by NSF in the country and the only one focused on preventing child and young adult injuries. CChIPS is currently in the third year of the five-year grant renewal, allowing us to continue our important work.

With the addition of The Ohio State University (OSU) as our second research site in 2011, CChIPS has expanded and established itself as a multi-university Center. This partnership has strengthened our resources with leading investigators and cutting-edge facilities, as well as diversified our research portfolio with new research thrust areas, including Sports Injury Prevention. The OSU site, led by John H. Bolte IV, PhD, hosted the fall IAB meeting in November 2012.

Continuing to share the latest research on occupant safety and other road traffic injury issues for children and adolescents with professionals from industry, nonprofits, government, and research organizations, CChIPS hosted the Advances in Child Injury Prevention (ACIP) Conference in May 2012 in Plymouth, MI. Over 83 attendees from 37 organizations heard a dozen presentations from experts at The Children's Hospital of Philadelphia (CHOP), The Ohio State University, the University of Michigan Transportation Research Institute, and the National Highway Traffic Safety Administration. Julie Gilchrist, MD, a medical epidemiologist in the Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control at the Centers for Disease Control and Prevention (CDC), served as the keynote speaker.

With a strategic plan co-developed by the faculty and IAB in 2011 serving as a guide for achieving our goals, CChIPS continues to spread its important mission and message of injury prevention worldwide. Center faculty and investigators have presented at SAFER, the Vehicle Safety Research Center at Chalmers University in Sweden, the World Injury Conference in Auckland, New Zealand, and the Protection of Children in Cars Conference in Munich. In March 2012, CChIPS Co-director Flaura Winston, MD, PhD testified as one of four invited witnesses at a Congressional hearing in Washington, DC about the prevalence of traumatic brain injury (TBI), types of TBI treatment, and legislative efforts to improve treatment programs. Dr. Winston's remarks put a special emphasis on pediatric TBI and the importance of preventing these often avoidable injuries in children.

The success of CChIPS, as explored in this report, shows the tremendous impact industry, academia, nonprofits, and government can achieve when working collaboratively toward mutual goals. We look forward to sharing many more achievements with you in the future.

A Unique Approach to Child Safety Research

Hosted by The Children's Hospital of Philadelphia Research Institute, one of the largest pediatric research facilities in the world, CChIPS takes a unique approach to child safety research. The Center was initially created to address Road Traffic Injury, the leading cause of injury and death for children and young adults, and has expanded to include Sports Injury Prevention. Our researchers work side by side with industry members to conduct translational research that is relevant to industry. This synergistic collaboration is ideal for generating ideas for new research projects and sharing expertise and resources.

The fundamental idea behind our work is that children are not small adults (mechanically, psychologically, developmentally, and socially). Therefore, child injury deserves to be examined and understood as a distinct branch of science. As automotive design and consumer behavior become increasingly complex, enhanced research, product development, and education efforts are necessary to further child safety. In just eight years CChIPS has conducted 55 projects with researchers partnering with leading automotive manufacturers, restraint suppliers, insurance providers, and government agencies to translate their findings into tangible innovations in safety technology and public education programs.

The CChIPS research method applies the broad and diverse backgrounds of its investigators to create and implement novel integrated approaches. For example, work in Child Crash Injury applies Biomechanical Epidemiology, an approach developed by CChIPS investigators. Currently, the majority of CChIPS research is focused on preventing road traffic injuries and deaths. Areas of research include:

- injury biomechanics, mechanisms, and tolerance
- technological solutions to injury (design, development, and testing)
- how humans interact and behave in relation to safety technology
- safety promotion and education
- the evaluation of safety devices and behavior modification programs

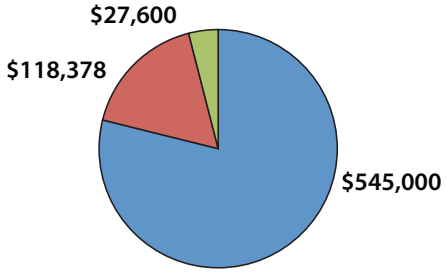
With the addition of The Ohio State University and several new IAB members, the Center is also in the process of exploring different research thrusts, including Sports Injury Prevention and Orthopedic Biomechanics. To learn more about CChIPS or to sponsor research with CChIPS investigators, visit cchips.research.chop.edu or e-mail Eve Weiss, MS, CChIPS project manager, at weisse2@email.chop.edu.

CChIPS continues to spread its important mission and message of injury prevention worldwide.

Funding the Research

CChIPS is made possible through a grant from the National Science Foundation (NSF), as well as sponsorships from its Industry Advisory Board (IAB) member companies, comprised of industry, academia, nonprofits, and government, that engage in scientific research and development to improve child safety. Every year, each full voting IAB member contributes $50,000 to support the CChIPS mission. Non-voting government and nonprofit organizations and small businesses are also given the opportunity to join for a reduced annual fee. These memberships are designed to boost organization and small business involvement in the CChIPS mission and to spur innovation. To become a member or to sponsor research with CChIPS investigators, contact Eve Weiss, MS, CChIPS project manager, at weisse2@email.chop.edu.

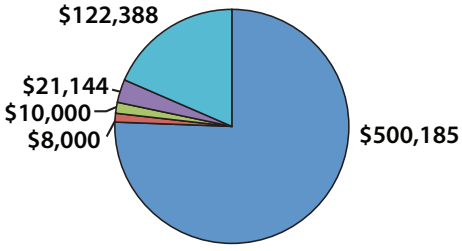
REVENUE FOR 2012



- Members' Contribution
- NSF Center Award & Additional Contributions
- NSF Supplemental Funding

*Total Revenue: $690,978

EXPENDITURES FOR 2012



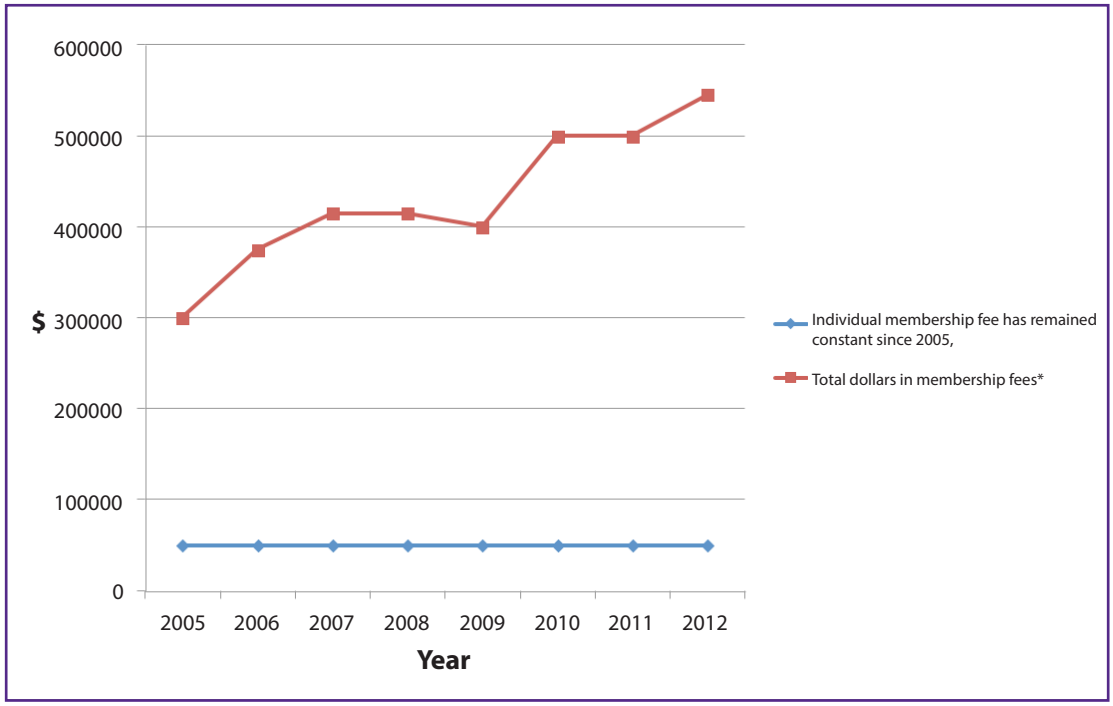
- Projects Awarded (IAB Funding)
- REU Supplement (NSF Funding)
- RET Supplement (NSF Funding)
- Meeting Expenses (ACIP & IAB Funding)
- Admin/Operating Expenses

*Total Expenses: $661,717

The Children's Hospital of Philadelphia Research Institute waives overhead expenses for CChIPS.

Return on Investment

On average since CChIPS began in 2006, each full voting Industry Advisory Board (IAB) member has contributed an annual $50,000 membership fee as an opportunity to influence the direction of the CChIPS research agenda. In 2012, the combined membership fees resulted in $545,000 available to support the mission of CChIPS. Based upon the $50,000 membership fee, this represents a 990% annual Return on Investment (ROI) per company.



*Membership fees only constitute a portion of total funding available for CChIPS.

Preparing Future Industry Scientists

Training students is an important part of the CChIPS mission. We are committed to creating a diverse, internationally competitive, and globally engaged science and engineering work force with a focus on injury prevention. Our rigorous, meaningful research projects and talented investigators and IAB members allow us to attract a diverse pool of talented students. These students also bring fresh ideas and energy to our studies. To date, over 55 students have played key roles in CChIPS research projects.

Each spring The Ohio State University hosts the Injury Biomechanics Symposium, where students from universities around the world are invited to present their research projects. Several CChIPS students have participated in this symposium, which provides a unique atmosphere for professional communication between developing and established researchers.

Research In Action: 2011-2012 Project Highlights

Biomechanical Response of the Pediatric Ankle

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

Co-investigator:
Ajit Chaudhari, PhD, The Ohio State University

Student:
Laura Boucher, The Ohio State University

IAB Mentors:
Doug Longhitano, Honda R&D Americas Inc.; **Christina Mullen**, State Farm Mutual Automobile Insurance Company; **Rodney Rudd**, National Highway Traffic Safety Administration

Pediatric volunteer undergoing testing on the Biodex

An increased risk of injury to the leg occurs when a child is placed in a child restraint's forward-facing position. In a frontal collision, the leg can make contact with the front seatback, causing fairly common and often very serious injuries to the tibial growth plates and ankle joint. Since the pediatric anthropomorphic test device (ATD) has no instrumentation below the knee, it makes it impossible to evaluate the amount of force the leg experiences on impact during frontal collisions. Moreover, because the pediatric ATD does not have a realistic ankle, it is not possible to directly measure these forces to accurately predict injury to the leg.

The aims of this study were to measure the lower extremity anthropometry of 42 children, ages 4 to 12 years, as well as to determine ankle stiffness and the ankle's range of motion (ROM) in four ways: 1) while standing on one's toes (plantar flexion), 2) while rotating the foot backward to bring the toes closer to the ankle (dorsiflexion), 3) while rotating the foot so the sole is pointing inward (inversion), and 4) while rotating the foot so that the sole is away from the body (eversion). Seventeen different measurements were taken bilaterally on the foot, ankle, and leg. Using a hand-held goniometer, ROM was measured both actively (flexing) and passively (naturally) in plantar flexion. Ankle stiffness was measured using an Isokinetic Dynamometer in six directions: plantar and dorsiflexion, inversion and eversion in an anatomical position, and inversion and eversion in a relaxed position.

Overall, the study found that younger children have an increased available ROM in all directions measured. Differences did exist between the younger group (ages 4 to 7 years) and the older group (ages 8 to 12 years), especially involving dorsiflexion with both a straight leg and bent knee, as well as actively and passively. The information gained from this study will benefit the automotive industry by helping to produce a more lifelike ankle in both the 6- and 10-year-old ATDs. It also provides beneficial information to the rehabilitation community working with children with gait abnormalities and spasticity disorders.

Research In Action: 2011-2012 Project Highlights

Clavicle Fractures Due to Belt Loading in Rear-Seated Adolescent Occupants

Principal Investigators:

Jason Stammen, PhD, NHTSA; **John H. Bolte IV, PhD**, The Ohio State University; **Kristy Arbogast, PhD**, The Children's Hospital of Philadelphia

Co-investigators:

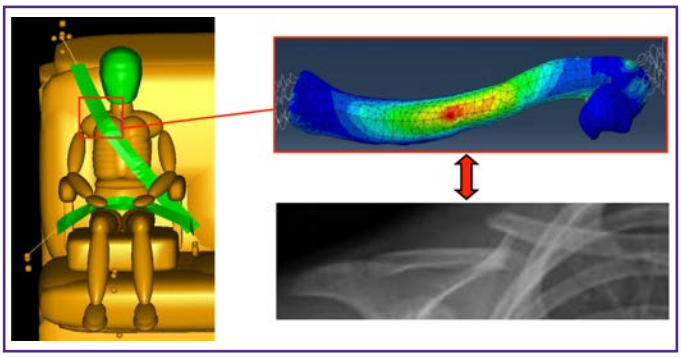
Caitlin Locey, BA and **Matthew R. Maltese, PhD**, The Children's Hospital of Philadelphia; **Rebecca Dupaix, PhD**, The Ohio State University; **Dan Parent, PhD**, National Highway Traffic Safety Administration

Students:

Travis Jones and **Rakshit Ramachandra**, The Ohio State University

IAB Mentors:

Doug Longhitano, Honda R&D Americas Inc.; **Rodney Rudd**, National Highway Traffic Safety Administration; **Julie Kleinert**, General Motors Holdings LLC



Pictured clockwise left to right: CIREN case MADYMO reconstruction with scaled 6-year-old ATD model seated in 3-point belt with backless booster; FE age-matched pediatric clavicle with stress distribution resulting from ATD shoulder belt contact loading in MADYMO reconstruction; X-ray of clavicle fracture from corresponding CIREN case

Little is known about the dynamic response of the adolescent occupant shoulder when seat belt restrained in a frontal or off-center crash. Pediatric clavicle fractures attributed to shoulder belt loading, while rare, provide a glimpse into how the belt-shoulder interaction changes with crash speed, the principal direction of force, restraint type, and belt anchor locations within the vehicle.

Investigating cases of clavicle fractures sustained by seat-belt-restrained pediatric occupants provides guidance for developing improved shoulder designs in child-sized anthropomorphic test devices (ATDs). The goals of the study were to determine the crash characteristics typically associated with clavicle fractures, with consideration for age-related differences in injury patterns and restraint conditions, and to estimate the level of force required to cause injury to the adolescent clavicle through paired match case reconstructions with a Hybrid III ATD model.

Real world crash data was collected from the National Highway Traffic Safety Administration's Crash Injury and Research Engineering Network (CIREN) and the National Automotive Sampling System – Crashworthiness Data System (NASS-CDS). The data collected included age, seating position, type of restraint, extent of vehicle damage, crash velocity, and injuries.

Differences in injury patterns between front- and rear-seated occupants, as well as between adult and adolescent occupants, were observed in NASS-CDS data. Younger occupants appeared to have a greater risk of thoracic organ injuries, while older occupants tended to have more skeletal (rib, sternum, and clavicle) injuries due to the belt. Also, lumbar vertebral fractures were more common in younger occupants, reflecting the greater propensity for the lap belt to ride up on the occupant's abdomen rather than fitting properly over the hips.

The data were further analyzed to identify patterns associated with clavicle fractures, including the presence of attendant serious head and thorax injuries. Four CIREN cases with a seat belt-induced clavicle fracture were selected, along with four cases without clavicle fracture matched to the injured cases by occupant, vehicle and crash characteristics. These eight cases were reconstructed using a combination of a computational modeling of the crash and a 3D finite element (FE) model of the clavicle created from real patient medical imaging. Vehicle-specific seat geometries and crash pulses were used to replicate the case information as closely as possible, and shoulder-belt contact forces obtained from the computer simulations were used as input to the FE clavicle, which had age-appropriate mechanical properties developed from literature studies. Differences in stress (the amount of force per area) magnitude between fracture and non-fracture cases were quantified with respect to both ATD shoulder forces and radiological fracture locations.

By drawing relationships between cases where the clavicle was injured and not injured, the researchers can provide guidance for improved ATD shoulder design, as well as loading thresholds indicative of clavicle fracture for vehicle and child seat design.

Child Restraint System Misuse in the Field and in Full-Vehicle Crash Tests

Principal Investigator:

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

Co-investigators:

Mark Zonfrillo, MD, MSCE and **Kristy Arbogast, PhD**, The Children's Hospital of Philadelphia;
Suzanne Tylko, MSME, Transport Canada

Student:

Melanie Ward, University of Michigan

IAB Mentors:

Uwe Meissner, Technical Advisor; **Keith Nagelski**, Britax Child Safety Inc.; **Eric Dahle**, Evenflo Co. Inc.;
Doug Longhitano, Honda R&D Americas Inc.; **Richard Bandstra**, Volkswagen Group of America Inc.

An example of belt routing misuse

Motor vehicle crashes continue to be the leading cause of death for children in the U.S., Canada, and Europe, and child restraint systems (CRS) can significantly reduce the risk of injury. Studies show, however, that CRS misuse can lead to less than optimal injury prevention when crashes occur. This improper CRS use includes not using the appropriate CRS for the child's age, incorrectly attaching the CRS to the vehicle, and not harnessing the child in the CRS correctly.

To understand the real world restraint practices of the CRS consumer, in phase 1 of this study we examined 10,000 CRS inspection forms from the Pennsylvania American Academy of Pediatrics (PA-AAP) Traffic Injury Prevention Project (TIPP) from 2007-2010. Data collected included descriptive variables of the CRS consumer and child including child anthropometry; vehicle and CRS variables including year, make and model; CRS condition variables, including damage assessment and condition of labeling, and misuse variables specific to the common CRS types (rear facing (RF) Infant, RF Convertible CRS, forward facing (FF) CRS, Booster) and restraint fit information for children in belt restraints. Three broad categories of misuse were considered: 1) improper restraint selection or placement in the vehicle, 2) incorrect or loose CRS-to-vehicle attachment, and 3) incorrect or loose restraint of the child in the CRS.

The results revealed important characteristics of the CRS consumer. We noted that children in rear-facing CRS were seated in the right front passenger seating position with an active air bag (3% of rear-facing CRS misuses) relatively infrequently. We also found that the LATCH attachment method was used in slightly more than half (51%) of all rear-facing CRS misuse conditions. One of the most common misuses in forward-facing CRS was loose attachment between the CRS and vehicle. Of note, the frequency of this type of misuse in LATCH cases (11%) was less than half than that in belt cases (26%). This suggests LATCH allows a greater percentage of parents to achieve a tighter fit on the CRS in the vehicle. To a lesser extent, this same effect was observed in rear-facing CRS, with belt or LATCH use roughly evenly split in the sample — with 13% of LATCH CRS found to be loose vs. 18% of belted CRS found to be loose.

We found that different types of misuses often occur together, suggesting that parents and caregivers are often generally misusing CRS rather than having difficulty mastering a single aspect of CRS installation. Incorrect tether use was often associated with other misuses of CRS-to-vehicle attachment, such as belt routing, improper LATCH use, and general looseness of the restraint. Incorrect choice of the harness slot was frequently seen with other harness-related misuses, such as improper harness retainer (chest) clip position and loose or misthreaded harness. Efforts to improve ease of use or clarity of instructions, combined with effective public safety messaging emphasizing the importance of proper CRS use, is warranted.

In phase 2 of this study, we sought to provide the scientific basis to prioritize child restraint misuse as a function of injury risk and to demonstrate the consequences of the misuse through high quality, high speed video imaging obtained during actual motor vehicle crash testing. Testing was conducted in the second row seat of passenger vehicles undergoing full frontal rigid barrier crash tests at 40 and 48 km/h. Two identical child restraints and ATDs were installed in each of the rear outboard positions of the test vehicles: One child restraint was "correctly installed" as per manufacturer instructions behind the driver seat, and the second identical child restraint was "incorrectly installed" behind the right front passenger seat to characterize one or more of the misuse conditions identified in the literature or field studies. The video images will provide valuable visual aids for professionals striving to reduce child restraint misuse in the field and will be an important scientific basis for future child seat regulatory initiatives.

Research In Action: 2011-2012 Project Highlights

Comparing FMVSS 213 Sled Test to the Full-scale Vehicle Crash Environment – Year 2

Principal Investigator:

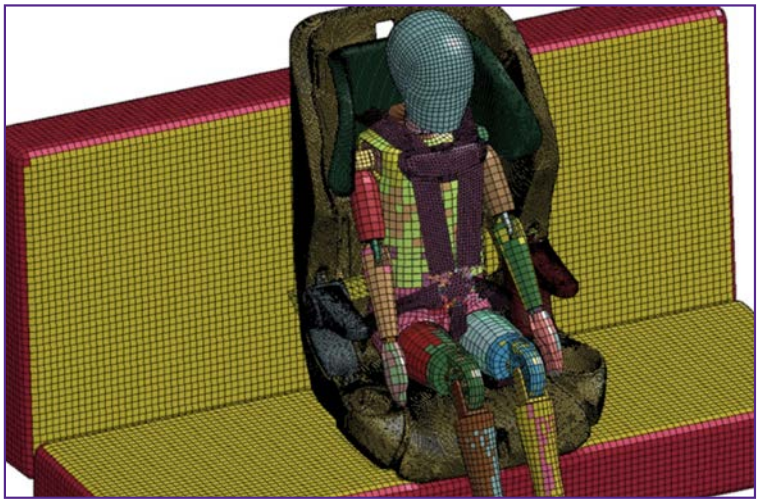
Matthew R. Maltese, PhD, The Children's Hospital of Philadelphia

Co-investigators:

Aditya Belwadi, PhD, Caitlin Locey, BS, and **Kristy Arbogast, PhD,** The Children's Hospital of Philadelphia; **Suzanne Tylko, MSME**, Transport Canada.

IAB Mentors:

Uwe Meissner, Technical Advisor; **Richard Bandstra**, Volkswagen Group of America Inc.; **Eric Dahle**, Evenflo Co. Inc.; **Keith Nagelski**, Britax Child Safety Inc.; **Schuyler St. Lawrence** and **Kazuo Higuchi**, TK Holdings (Takata Corp.); **Rajiv Menon**, Dorel Juvenile Group



Hybrid III 6-year-old ATD in a forward-facing child restraint on the C/FMVSS bench in a finite element simulation

Keeping children safe in cars during crashes is an important area of injury prevention research. Aftermarket child restraint systems (CRS) provide protection during crashes but are evaluated by a regulatory sled test that may differ from full-scale vehicle crash conditions in important ways. The long-term goal of this research is to influence CRS design and safety by developing a method to provide data-driven guidelines for the regulatory sled tests used worldwide by evaluating their ability to mimic actual vehicle crashes.

Since it is vital to understand CRS performance in conditions representative of an actual crash, this project, conducted in two phases, aims to quantify the extent to which the FMVSS 213 sled test simulates a frontal vehicle crash test. FMVSS 213 is the regulation that governs evaluation of child restraint performance. Child restraints are tested in a dynamic sled test while mounted on a bench seat that is intended to mimic the rear seat of a vehicle.

The first phase of the study, conducted in 2010-11, helped to quantify the differences between the vehicle and bench seats. Paired sled tests were conducted in which the same child restraint was tested on the FMVSS 213 bench seat, as well as a selection of actual vehicle seats.

Results from our first year of research show clear differences in the kinematics of both the ATD and the child restraint when exposed to identical crash pulses between the FMVSS 213 bench currently used for CRS regulatory testing and actual rear seats from a representative passenger car, SUV, and minivan, each mounted on an acceleration sled.

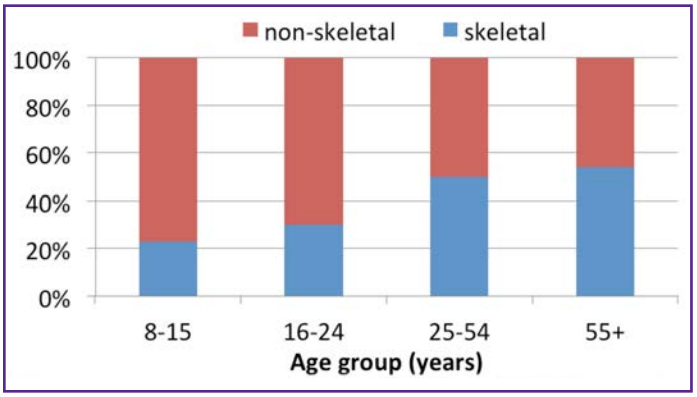
The second phase, conducted in 2011-2013, is discovering why these differences occur. We are currently determining which characteristics of the regulatory bench seat (seat cushion stiffness, seat belt stiffness, seat belt/LATCH/tether anchor location) led to these differences by utilizing a finite element model of the FMVSS 213 bench with a forward-facing CRS and an appropriately-sized ATD. We are conducting a matrix of simulations that is evaluating how changes in these parameters influence ATD kinematics in order to identify the set of parameters that result in kinematics that are similar to those observed in the tests on the actual vehicle seats.

Injury Risk to Belted Occupants – Year 2

Principal Investigator:
Kristy Arbogast, PhD, The Children's Hospital of Philadelphia

Co-investigators:
Caitlin Locey, BS and **Mark Zonfrillo, MD, MSCE**, The Children's Hospital of Philadelphia

IAB Mentors:
J.T. Wang and **Julie Kleinert**, General Motors Holdings LLC; **Rodney Rudd**, National Highway Traffic Safety Administration; **Schuyler St. Lawrence**, TK Holdings (Takata Corp.).



Distribution of skeletal versus non-skeletal thoracic injuries versus age

This study is a continuation of a previous CChIPS project conducted in 2010-2011 that quantified the injury and fatality risk for both children and adults who are optimally restrained. Researchers found an elevated injury risk experienced by 8- to 12-year-old passengers that followed best practice recommendations for seat belt restraint as compared to the risk experienced by younger children. Adult injury risk in crashes varied by whether a child occupant was present due to differences in key vehicle and crash characteristics when adults drive alone or with child occupants.

In this second phase of the project, researchers explored thoracic injuries and why they occurred in optimally restrained rear-seated children and adults to understand if preteens and adolescents sustain different types of injuries in crashes. Using data from the Crash Investigation Research and Engineering Network (CIREN), the researchers examined 20 frontal crash cases involving rear-seated, optimally restrained occupants ranging in age from 8 to 55+ years with AIS2+ thoracic injuries. Six of the seven 8- to 15-year-olds sustained lung injuries, including collapsed lung (pneumothorax) and bruised lung (pulmonary contusion). Only three of the seven sustained a skeletal (sternum or rib) fracture, with only one of the three involving multiple ribs bilaterally. In contrast, four of the five 16- to 24-year-olds sustained at least one rib fracture, with most multiple and bilateral. Although the adults, ages 25 years and older, were predominantly involved in minor crashes, they all suffered complex rib fractures, with seven of the eight involving multiple ribs and half bilaterally. Belt compression – either from the shoulder belt or the lap belt – was identified as the primary cause of these injuries. These findings have implications for age-based thoracic injury criteria suggesting that different metrics may be needed for different age groups.

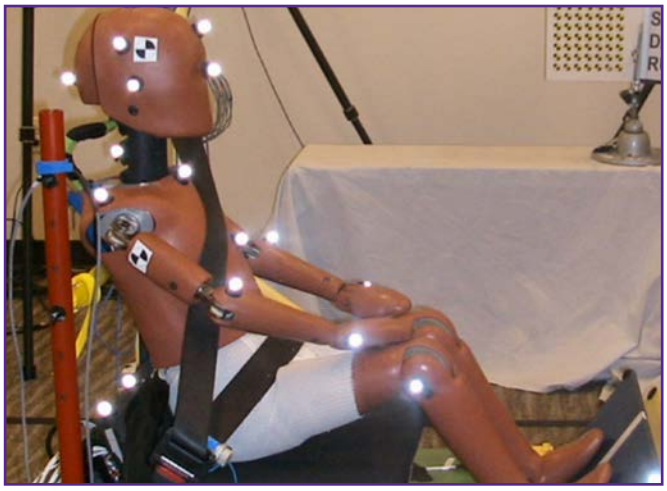
Dynamic Comparison of Pediatric and the 5th Percentile Female Anthropomorphic Test Devices (ATDs)

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

Co-investigators:
Kristy Arbogast, PhD, Matthew R. Maltese, PhD, and **J. Felipe Garcia-Espana, PhD**, The Children's Hospital of Philadelphia

Student:
Marina Samuels, Brigham Young University

IAB Mentors:
Doug Longhitano, Honda R&D Americas Inc.; **Dan Robertston**, Toyota North America Inc.; **Jerry Wang**, Humanetics; **Schuyler St. Lawrence**, TK Holdings (Takata Corp.).



The Hybrid III 6-year-old ATD outfitted with photo-reflective targets

The goal of this study was to compare the response of the Hybrid III 6- and 10-year-old anthropomorphic test devices (ATDs) developed in the U.S., and the Q-Series 6- and 10-year-old ATDs developed in Europe to that of matched pediatric volunteers in low-speed frontal crashes. The researchers also compared the Hybrid III 5th Female ATD, approximately the size and weight of an average 12- to 13-year-old, to teenage volunteers.

Using previously collected low-speed, non-injurious frontal crash tests on 6- to 14-year-old volunteers, the researchers compared ATD responses in identical tests to matched volunteers. Photo-reflective targets were placed on the head, neck, spine, and pelvis and tracked using a 3D target tracking system. Seat belt and seating environment reaction loads were also measured. Results showed that when compared to the response of human volunteers, the ATDs significantly underestimated head, neck, spine, and pelvis forward excursion, overestimated shoulder and lap belt loads (particularly when examining the 6-year-old ATD response), and underestimated the force placed on the seat. These data provide useful information regarding the accuracy of the ATDs in low-speed crash conditions and will be used to help create more biofidelic pediatric ATDs for preventing injuries in low-speed crashes.

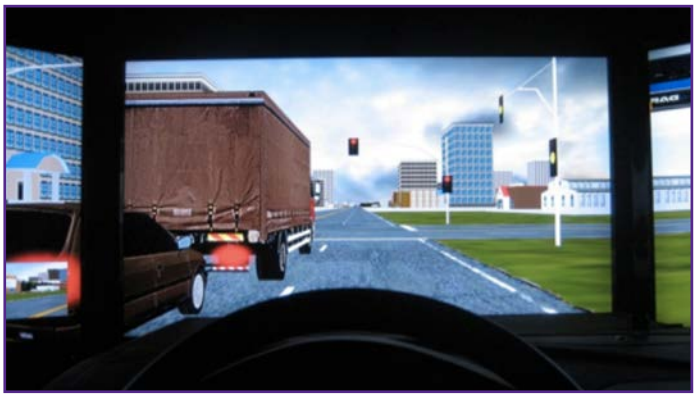
Research In Action: 2011-2012 Project Highlights

The Effect of Distraction on Teen Driving Performance in an Emotionally Realistic Driving Simulator

Principal Investigator:
Yi-Ching Lee, PhD, The Children's Hospital of Philadelphia

Students:
Catherine Smith, Temple University; **Michael Chang**, Drexel University

IAB Mentors:
Clayne Woodbury, RealTime Technologies Inc.;
Christina Mullen, State Farm Mutual Automobile Insurance Company;
Doug Longhitano, Honda R&D Americas Inc.



A view from one of the study's experimental drives in CHOP's driving simulator

A main reason why teens crash is being distracted while driving. This study, conducted in CHOP's driving simulator, examined how young novice drivers handle typical stressful traffic events, such as a motorcycle running a red light and a car backing out of a driveway while being concurrently distracted. The 16- to 20-year-old participants had their license for six months or less. After collecting their risk perceptions, cognitive flexibility (the ability to shift thoughts or actions as demanded by the situational context), and decision-making about risk-taking, participants practiced driving in the simulator. They then took two experimental drives that included a mixture of driving environments (e.g., city, highway) with different speed limits, surrounding traffic, buildings, and landmarks and were asked to imagine themselves going into the city to attend an event. Besides being instructed to follow all traffic laws and to drive safely, participants were concurrently distracted by being asked to provide a verbal answer as quickly as possible to math questions they saw on the simulator screen. To encourage attention to the distracting event, the participants were offered a performance bonus for answering the questions.

The two experimental drives contained ten traffic events and some of the math questions occurred while the traffic events were unfolding. The project is currently in the data management and analysis phase. We compared participants' cognitive flexibility and their performance on the math calculations. Teens who demonstrated lower cognitive flexibility performed worse on the math calculations. This finding suggests that the secondary in-vehicle task is successfully manipulating teens' directed attention, and we are exploring the effect on driving skills.

Long-term Disability Following Pediatric Trauma

Principal Investigator:
Mark Zonfrillo, MD, MSCE, The Children's Hospital of Philadelphia

Co-investigators:
Dennis R. Durbin, MD, MSCE, The Children's Hospital of Philadelphia;
Margaret G. Stineman, MD, The University of Pennsylvania

Student:
Melanie Ward, University of Michigan

IAB Mentors:
Uwe Meissner, Technical Advisor; **John Combest**, Nissan Technical Center North America Inc.; **Dan Robertston**, Toyota North America Inc.

While injury remains the leading cause of death for children ages 1 year and older in the U.S., 95 percent of pediatric patients with moderate to severe trauma survive. These non-fatal, yet serious injuries can have significant short-term and long-term consequences on these young patients' functionality and quality of life. There is great value in understanding the epidemiology of injury-related disability in order to inform primary, secondary, and tertiary prevention efforts. The ultimate objective of rehabilitation for injured children is to maximize function and enable their return to home, school, and community.

This retrospective 10-year study of 13,798 patients ages 7 to 18 years old that underwent inpatient rehabilitation for a broad range of traumatic injuries at 523 facilities across the country was the first contemporary assessment of physical disability following rehabilitation. Patients were identified from the Uniform Data System for Medical Rehabilitation (UDSMR) and functional outcome was measured with the Functional Independence Measure (FIM) instrument, composed of items in motor and cognitive domains. Although the FIM measures both physical and cognitive functionality, this study focused solely on the physical grade at discharge, ranging from Grade 1 (the patient needs total assistance) to Grade 7 (the patient has full functional independence).

While most children (70 percent) at admission to rehabilitation were at Grade 1, there was an overall improvement in their FIM score by discharge, with a most frequent Grade of 4 out of a possible 7. This suggests that only the most severely injured children are being referred to inpatient rehabilitation and somewhat less severely injured children may not be receiving this level of care. Among the most severely injured, children with spinal cord injuries accounted for 21 percent of patients, had longer lengths of stay (30-day median), and greater residual physical disabilities at discharge (Grade 2 median) as compared to children with traumatic brain injury and other forms of trauma who had a 15-day median length of stay and a median Grade of 4 at discharge.

Results of this study were published in the January 2013 issue of *Pediatrics*. Future work should consider assessment of functionality from more specific patterns of injuries and disparities in outcomes for age, gender, and socioeconomic status, as well as understanding influences of primary prevention efforts, pre-hospital care, emergency acute care, and intensive care on functional outcomes following trauma.

Supplemental Research Funding

Research Experiences for Undergraduates

After a competitive application process, CChIPS faculty were awarded a National Sciences Foundation Research Experiences for Undergraduates (REU) site for Injury Science. In 2012, its second year, 321 students applied for eight internships. Students spent the summer working side-by-side with Center for Injury Research and Prevention (CIRP) researchers.

CIRP's 10-week REU program provides a diverse group of student scholars from schools across the country with mentorship and hands-on research experience in the fields of Engineering, Behavioral Science, and Epidemiology. Each student is paired with a CIRP mentor to work on specific projects and also receives formal training in research ethics, research methodology, and the presentation of research findings.

Looking Beyond Catastrophic Brain Injury to Mild Traumatic Brain Injury

Led by Kristy Arbogast, PhD, CIRP director of Engineering and co-director of CChIPS, this study expands the Center's areas of research to include Sports Injury Prevention. Motor vehicle crashes (MVCs) are the leading cause of traumatic brain injuries (TBI) in children and youths. Overall, the majority of TBIs that occur each year are concussions or other forms of mild TBI (mTBI). Studying young athletes presents an ideal environment in which to research mTBI due to its frequency and observability.

In this study, the researchers are examining helmet-based sensors on youth hockey players to validate their ability to accurately measure head acceleration with the long-term goal to quantify head biomechanics and correlate with neurocognitive deficits across a typical season. This research is being conducted in collaboration with CChIPS members Toyota North America Inc. and the National Highway Traffic Safety Administration, as well as SAFER, the Vehicle and Traffic Safety Centre at Chalmers University in Goteborg, Sweden.

This research is part of CIRP's cutting-edge work in Pediatric Biomechanics, which is crucial to filling the gaps in knowledge to make more accurate pediatric anthropomorphic test devices (ATDs). With this knowledge, CHOP's biomedical engineers and others are implementing novel approaches to measure how children respond to the forces of a crash and to estimate their bodies' tolerance to various types of injury. The data collected will help scientists better evaluate the potential for concussion in the event of a MVC and to increase their knowledge of appropriate ATD injury metrics and associated thresholds.

Synergy In Motion

Sponsoring industry members play an integral role in setting the research agenda for CChIPS. These members comprise the Center's Industry Advisory Board (IAB). Membership is open to all companies, organizations, or federal agencies that have an interest in advancing research and development to further child and adolescent injury prevention. The IAB selects a Chair and Secretary to serve for a two-year term. IAB meetings are held twice a year, in spring (to select the research portfolio for the upcoming year and hear results from projects funded in the previous year) and in the fall (to review progress and provide insights to the current year's research portfolio and to select ideas for proposal submissions for the subsequent year). A formal process of proposal submissions involving extensive discussions with designated IAB mentors immediately precedes the annual spring meeting. At that meeting, the Board votes on the proposals, ranking them based on points allotted.

Besides helping to choose the research to be performed, IAB members provide valuable feedback on projects already underway, both as project mentors and in review of project progress and results, and provide guidance in strategic planning for the Center.

Every membership dollar goes toward research and its dissemination. The CHOP Research Institute, The University of Pennsylvania, The Ohio State University, and other research facilities involved in CChIPS projects waive overhead fees to make this vital work possible. IAB members also can rely on CChIPS' proven track record in successful research partnerships with industry and government. In addition to regular interactions with virtually all automotive-related organizations concerned with child safety, the Center has conducted specific research projects with major original equipment manufacturers, restraint suppliers, insurance providers, and government agencies.

2011-2012 IAB Member Companies included:

- Britax Child Safety Inc.
- Chrysler Group LLC
- Consumer Union
- Dorel Juvenile Group
- Evenflo Company Inc.
- Ford Motor Co.
- General Motors Holdings LLC
- Honda R&D Americas Inc.
- Humanetics
- Minnesota HealthSolutions
- The National Highway Traffic Safety Administration
- Nissan Technical Center North America Inc.
- Parallel Consulting
- RealTime Technologies Inc.
- State Farm Mutual Automobile Insurance Company
- TK Holdings (Takata Corp.)
- Toyota Motor North America Inc.
- Transportation Research Center Inc.
- Volkswagen Group of America Inc.

Center for Child Injury Prevention Studies

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Center for Child Injury Prevention Studies

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