Safe and Sound

The Center for Child Injury Prevention Studies 2010 Annual Report

The Children's Hospital *of* Philadelphia®
RESEARCH INSTITUTE

The Ohio State University Medical Center

Partnering for Safety

A MESSAGE FROM OUR DIRECTORS

Kristy Arbogast, Ph.D., John H. Bolte IV, Ph.D., and **Flaura Winston, M.D., Ph.D.,** co-directors, CChIPS

Safe and sound. That's what parents hope for and our Center works toward. In fact, the future is bright for advancing child safety through evidence-based research. The Center for Child Injury Prevention Studies (CChIPS) at The Children's Hospital of Philadelphia Research Institute is proud of its achievements in 2010. Through a unique partnership with our Industry Advisory Board (IAB), our researchers continue to pinpoint and assess the causes of injuries to children and young adults. With this knowledge, they prevent injuries and engineer solutions that save children's lives. We are excited to share research highlights in this report.

Founded in March 2005 with a grant from the National Science Foundation (NSF), CChIPS is one of more than 50 Industry/University Cooperative Research Centers (I/UCRCs) funded by NSF in the country and the only one focused on preventing child and young adult injuries. We achieved several important milestones last year that deserve recognition. In January 2010, we secured a prestigious position as a Phase II I/UCRC after successfully submitting a renewal grant to NSF. This five-year renewal allows us to continue our important work through 2015.

CChIPS is also expanding. We are thrilled to announce our partnership with The Ohio State University (OSU) to serve as our second research site. The site will be led by John H. Bolte IV, Ph.D., a professor in the College of Medicine, School of Biomedical Science, Division of Anatomy and the College of Mechanical Engineering, Mechanical and Aerospace Engineering at OSU. Becoming a multi-university site offers several advantages. It increases our pool of cutting-edge investigators, expands our capacity in orthopedic biomechanics and allows us to diversify into new research thrust areas such as sports injury prevention. The center's expansion lays the groundwork for sustaining CChIPS for years to come.

Some important transitions for CChIPS also occurred in 2010. Kristy Arbogast, Ph.D., director of the Engineering Core for the Center for Injury Research and Prevention at CHOP and a research associate professor of Pediatrics at The University of Pennsylvania Medical School, joins Flaura Winston, M.D., Ph.D., and Dr. Bolte as the new co-director of CChIPS. She replaces Sriram Balasubramanian, Ph.D., now an assistant professor in the Department of Biomedical Engineering at Drexel University in Philadelphia. Dr. Balasubramanian will continue to conduct research at the Center, along with his teaching responsibilities at Drexel.

CChIPS also bid adieu to two of its longstanding IAB members -- John Werner of State Farm Insurance Companies® and Uwe Meissner of Volkswagen Group of America Inc., who both retired from their corporate positions. Their dedication and vision helped position the Center for continued growth, and we wish them the best in retirement. Mr. Meissner will continue his involvement in CChIPS as a technical advisor.

Finally, 2010 provided a ripe opportunity to revisit our strategic goals. The Center formed a strategic planning subcommittee led by incoming IAB Chair Ken Wittenauer and developed a new three-year action plan and logic model to guide program operations. With this strategic roadmap in place, CChIPS is poised to share many more achievements with you in the years to come. The Center's success, as explored in this report, shows the tremendous impact industry and academia can achieve when working collaboratively toward shared goals.

A Unique Approach to Child Safety Research

CChIPS was founded in March 2005. One of more than 50 National Science Foundation Industry/University Cooperative Research Centers (I/UCRC) in the country, the Center is the only one focusing exclusively on preventing injuries to children and young adults. Hosted by The Children's Hospital of Philadelphia Research Institute, one of the largest pediatric research facilities in the country, CChIPS takes a unique approach to child safety research. Our researchers work side by side with industry members and other university scientists to conduct translational research that is practical to industry. This synergistic collaboration between industry and academia is ideal for generating ideas for new research projects and sharing expertise and resources.

CChIPS was created to address the predominant mechanism of child death – road traffic injury. The fundamental idea behind its 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 and outreach efforts are necessary to further child safety. In just five years CChIPS has conducted 43 research projects, with investigators 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 its investigators' broad and diverse backgrounds to create and implement novel, integrated approaches. Also, work in child crash injury applies biomechanical epidemiology, an approach developed by CChIPS investigators. This approach allows for highly efficient research designs to address problems that have stymied traditional, single discipline injury research approaches. For example, delineating the causative pathway for cervical spine injuries in children exposed to air bag deployment required an integration of biomechanics, epidemiology, and medicine. Defining the causes of novice teen driver crashes involved behavioral, cognitive, and social psychology; communication; anthropology; safety engineering; and adolescent medicine.

Currently, the majority of CChIPS research is focused on preventing road traffic injuries, the leading cause of injury and death for children and young adults. These areas of research include:

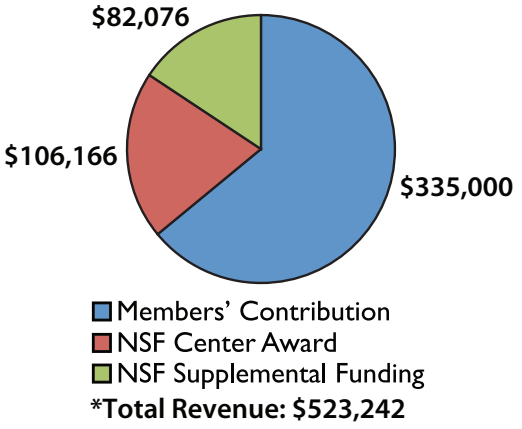
- injury biomechanics, mechanisms, and tolerance
- technological solutions to injury (design, development, and testing)
- human interaction and behavior in relation to safety technology
- safety promotion and education
- evaluation of safety devices and behavior modification programs

Plans are underway to develop additional research thrusts, including sports injury and orthopedic biomechanics. To learn more about CChIPS or to sponsor research with CChIPS investigators, visit www.chop.edu/cchips or e-mail Marek Sulzynski, CChIPS Coordinator, at SulzynskiM@email.chop.edu.

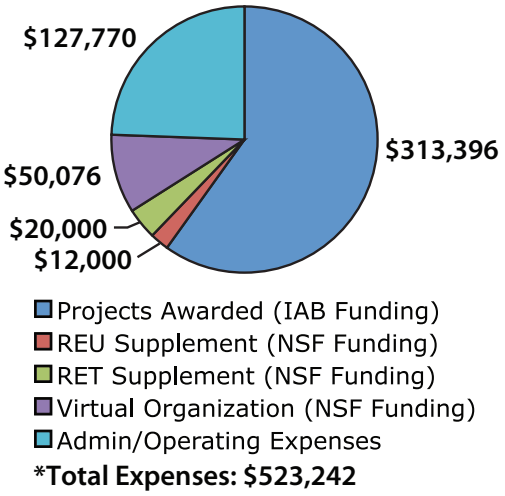
Funding the Research

CChIPS is made possible through a grant from NSF and its IAB member companies, comprised of industry and federal agencies that engage in scientific research and development to improve child safety. Each IAB member contributes $50,000 annually to support the CChIPS mission. Beginning in 2010, small businesses were given the opportunity to join as affiliate members for a reduced annual fee. These memberships are designed to boost small business involvement in CChIPS and to spur innovation. To become a member or to sponsor research with CChIPS investigators, contact Marek Sulzynski, CChIPS Coordinator, at SulzynskiM@email.chop.edu.

REVENUE



EXPENDITURES



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

Research In Action: 2009-2010 Project Highlights

Structural and Material Characteristics of the Pediatric Thoracic Cage and Their Relationship to Age-Related Changes in Thoracic Response

Principal Investigator:
Sriram Balasubramanian, Ph.D., Drexel University and The Children's Hospital of Philadelphia

IAB Mentors:
Chris Mullen, formerly with Toyota; **Steve Ridella**, NHTSA; **Steve Rouhana**, Ford

Today's child crash test dummies, also known as anthropomorphic test devices (ATDs), are basically smaller versions of adult-sized dummies with little consideration for differences in age-related body composition. This research study contributes to delivering the basic data needed to improve specific body regions of the pediatric ATDs and to develop innovative restraint products to make vehicles safer for children in the future. These advances will help save children's lives, prevent injuries, and reduce the economic cost of crashes involving child passengers.

The biofidelity of the ATD chest is critical because it is one of the primary load paths of a seat belt or child restraint harness. As children age, the ribs and sternum structurally change; bones fuse, and the ribs angle downward and twist. This study quantified the three-dimensional geometric characteristics of the pediatric thoracic cage for males ages 1, 3, 6 ,10, and 18 years using chest CT scans collected from CHOP patients via specialized software to visualize, segment and render 3D images of the pediatric torso. Based on these reconstructions, a custom code was created to compute several geometric parameters of the thoracic cage.

Age-specific geometric differences were observed in the pediatric thoracic cage structure for several geometric parameters, including rib length and lateral rib angle. The researchers also found that, on average, the apparent curvature of the thorax tends to decrease with age with the shape of the chest being more elliptical and less circular with age. In addition to helping to create more accurate child crash test dummies, this data can be applied to a wide range of technology applications to improve child safety, as well as medical training, including simulation tools and medical implant design and development.

Understanding the Learning to Drive Process for Teens with High-functioning Developmental Disabilities

Principal Investigator:
Patty Huang, M.D., The Children's Hospital of Philadelphia.

IAB Mentor:
John Werner, State Farm

This innovative study examined the relationship between teens with high-functioning autism spectrum disorder (HFASD) and driving to create driving profiles for the eventual creation of fitness-to-drive guidelines for parents and physicians. These profiles will provide the foundation for educational modifications and interventions for teens with autism and other high functioning developmental disabilities.

While teens with HFASD may be at risk for unsafe driving behaviors and may self-restrict around driving, their driving experience had not yet been studied. Dr. Huang and her team examined these teens' experience with driving, including frequency and timing of licensure, the functional characteristics associated with driving status and outcomes (including crashes and number of tickets received), and methods used to learn driving.

The researchers collected data using a web-based, 10- to 15-minute parent survey that included questions about teen driving status; factors parents consider in making decisions about their teens' driving; methods used to teach them how to drive; driving outcomes; parent characteristics; and teen autism characteristics. Subjects were recruited through the Interactive Autism Network, a national online research registry created by Johns Hopkins University and supported by Autism Speaks, a parent advocacy group.

The study found that a significant number of teens with HFASD are interested in driving. Because a substantial proportion of them also reported crashes and citations, education should focus on promoting driving safety for this population, as it does for teen drivers in general. Future research should be conducted to measure the driving performance of teens with HFASD using a variety of methods, including on-road and driving- simulator assessments.

Knee Air Bag Injury Risk Assessment for Children

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

IAB Mentor:
Doug Longhitano, Honda R&D Americas Inc.

Occasionally, devices designed to protect adults in MVCs can be physically hazardous to children. One example is frontal air bags. Although proven to save adult lives, they also have contributed to the deaths of 159 children between 1993 and 2003. This study was designed to determine what risks, if any, knee bolster air bags pose to child occupants restrained in the front seat. The study was conducted in three steps: 1) to determine the real world population most likely at risk by deployment of this type of air bag and the possible injury mechanisms this group would encounter; 2) to determine how the injury mechanisms can be properly evaluated in automobile testing; 3) to determine the level of risk for pediatric lower extremity injuries due to knee bolster air bags.

In order to ensure that the air bag testing would simulate realistic situations, data was collected from several real world crash sources and included typical children's ages, seating positions, types of restraint, common injuries, and injury mechanisms in front seat crashes. Several pieces of instrumentation were added to the Hybrid III 6-year-old anthropomorphic test device's lower extremities based on the expected injury mechanisms, including accelerometers, angular rate sensors, and force sensors. For each trial, 67 channels of data and three high-speed camera views were recorded.

Static tests were conducted using a stationary knee air bag module positioned in front of a vehicle seat. Five air bag deployment trials were completed using the Hybrid III 6-year-old ATD in a different position for each: properly restrained in a booster seat; sitting on the edge of the seat with feet on the floor; sitting on the edge of the seat with knees at the air bag module; leaning back in the seat with toes on the air bag module; and leaning back with heels on the air bag module.

Although the majority of the parameters studied did not reflect a high chance of injury, the test with subjects on the edge of the seat indicated the possibility of tibia fracture.

Better data collection methods, such as tibia load cells, should be implemented so that more reliable conclusions can be drawn. Also, the two tests involving subjects leaning back in the seat resulted in extremely high ankle rotation rates. In order to collect meaningful ankle data in the future, the biofidelity of the ankle joint on ATDs must be improved.

Distracted Driving in Teens With ADHD

Principal Investigator:
Despina Stavrinos, Ph.D., University of Alabama

IAB Mentor:
Uwe Meissner, Volkswagen

This important study funded by CChIPS and the University of Alabama Transportation Center provides critical information on the effects of central nervous system stimulant drugs on driving performance for teens with Attention Deficit Hyperactivity Disorder (ADHD). ADHD is a behavioral disorder in which an individual has a high level of activity and/or difficulty attending to tasks. Central nervous system stimulant medications are often prescribed to treat ADHD. These drugs have a calming effect and help improve concentration.

Researchers examined the driving behavior of teens with ADHD while taking these medications and without them in a virtual simulator while talking or texting on a cell phone. They explored whether the cognitive and behavioral deficits associated with ADHD impair driving performance in a way that resembles a distracted driver, as well as the role of stimulant medication in reducing risky driving for teens with ADHD.

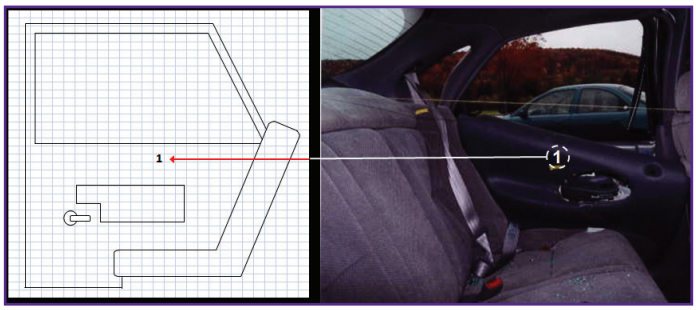
Forty-three 16- to 19-year-olds were recruited in a case-control design. Their driving behavior was assessed in a virtual simulator across two sessions: unmedicated and medicated. Level of distraction was later assessed, using no distractions first, then engaging them in a naturalistic cell phone conversation, and finally, in a naturalistic texting situation.

The researchers found that stimulant medications significantly impacted driving performance. When medicated, these teens were more effective and efficient drivers than when unmedicated. These findings are important to future intervention development for at-risk teen drivers, particularly those with ADHD, and also for clinicians and others serving the ADHD population to inform patients about medication management and driving.

Child Restraint Systems in Side Impact: Injury Patterns and Causation – Part II

Principal Investigator:
Kristy Arbogast, Ph.D., The Children's Hospital of Philadelphia

IAB Mentor:
Pankaj Amesar, formerly with Britax; **Uwe Meissner**, Volkswagen; **Rajiv Menon**, Dorel; **Stephen Oltman**, Dorel, **Hiromasa Tanji**, Takata



Although side impact crashes account for only 25 percent of all motor vehicle crashes (MVCs), they represent more than 40 percent of all MVC-related injury costs. Due to this fact, increased attention has been placed on better protecting children in child restraint systems (CRS). The aim of this study was to delineate injury causation scenarios for children placed in CRS involved in side-impact MVCs and to document probable contact points in the vehicle interior.

Two in-depth crash investigation databases, the Crash Injury Research and Engineering Network and the Partners for Child Passenger Safety Study, were queried for rear-seated, CRS-restrained children ages 0 to 8 in side impact crashes who sustained Abbreviated Injury Scale 2+ injury. These cases were reviewed by a multidisciplinary team of physicians and engineers to describe injury patterns, injury causation, and vehicle components contributing to the injuries; 41 occupants met the inclusion criteria (average age 2.6 years), with 24 seated near the side of the crash, 7 seated on the far side, and 10 seated in the center. The most common injuries were to the skull and brain, with a greater proportion of skull fractures occurring in older children. Lung contusions and spinal injuries were also reported.

Near-side head and face contact points were along the rear vertical plane of the window and the horizontal plane of the windowsill. Head and face contact points for center- and far-side occupants were along the edges of the front seat back and front seat head restraint.

These findings have implications for the future design of child restraints with side wings and energy management features on vehicle door interiors to reduce injuries from MVCs involving children placed in CRS.

The Association of Body Mass Index and Motor Vehicle Crash Injury Among 4- to 8-year-olds

Principal Investigator:
Mark R. Zonfrillo, M.D., The Children's Hospital of Philadelphia

IAB Mentors:
Rajiv Menon, Dorel; **Pankaj Amesar**, formerly with Britax, **Hiromasa Tanji**, Takata

This study aimed to determine the association between weight percentile and the risk of significant injury for children ages 3 to 8 involved in motor vehicle crashes (MVCs). Although it is well-known that the use of age-appropriate child restraint systems significantly reduces injury and death associated with MVCs, little is known about how the growing pediatric obesity epidemic in this country has affected MVC-related injury patterns.

This cross-sectional study sample was comprised of 9,327 3- to 8-year-olds involved in MVCs in 16 states with data collected via insurance claim records and an in-depth telephone survey. Parent-reported injuries with an Abbreviated Injury Scale score of 2+ indicated a clinically significant injury. Age- and sex-specific weight percentiles were calculated using pediatric norms.

According to the study findings, there was no association between weight percentiles and overall injury when adjusting for restraint type. However, higher weight percentiles were associated with a slightly higher rate of lower extremity injuries. This line of research may have long-term implications for vehicle and child restraint design for overweight children. Continued work in this area should focus on static and dynamic belt fit in overweight children and in child crash test dummies, also known as anthropomorphic test devices (ATDs).

Preparing Future 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 talented investigators, IAB members, and rigorous, meaningful research projects allow us to attract a diverse pool of talented students. These students also bring fresh ideas and energy to our studies. All of the projects, described on pages 3-6 of this report, involved student participation. To date, more than 43 students have played key roles in CChIPS research projects.

Supplemental Research Funding

As part of CChIPS' designation as a NSF center, Center faculty are eligible to apply for supplemental funding from NSF to advance the mission of CChIPS. Often this supplemental funding involves partnerships with other research organizations or university research centers across the country. In 2009-2010, these projects included:

- ***National Child Occupant Special Study (NCOSS)***
  Due to the changing landscape of restraint products, vehicle features, and child passenger safety (CPS) social norms, the development of a child-focused motor vehicle crash (MVC) surveillance system with sufficient size and data collection scope is urgently needed to provide direction to government, industry, and the public on how best to protect children. This coincides with the need to develop a nationally representative program that will provide data access for the CPS research community. The goal of this study, led by Allison Curry, Ph.D., director of Epidemiology at the Center for Injury Research and Prevention (CIRP) at CHOP, was to find the best way to adapt previous child specific data collection tools to create a shorter instrument, one that can be implemented via phone, Web, or self-administered hard copy. This newer version also would develop and evaluate the feasibility of subject selection, contact, and consent procedures. Dr. Curry and her team found that identification of cases for supplemental child-specific data collection, based on NHTSA's National Automotive Sampling System – General Estimates System, is feasible. This pilot study was conducted without disruption to the ongoing NASS-GES program, a critical design requirement of NHTSA's. Partners in this effort were Calspan, Westat, and NHTSA. Pilot studies continue to further evaluate the feasibility and logistics in setting up the NCOSS system.

- ***Transforming Traffic Safety Through Autonomic Computing: A Feasibility Study***
  The goal of this study, led by Dennis Durbin, M.D., M.S.C.E., co-scientific director of the Center for Injury Research and Prevention (CIRP) at CHOP, was to develop an initial prototype for a cyberinfrastructure for scientists from a wide range of disciplines to efficiently and effectively collaborate with relevant experts from industry and government to: 1) identify traffic injury problems, 2) share resources, data, and expertise to facilitate an in-depth study of their causes, and 3) promote rapid translation of results into new vehicle and restraint system designs, evidence-based safety regulations, and targeted public health injury prevention programs. The project built on a novel, collaborative partnership between government (National Highway Traffic Safety Administration and National Science Foundation), industry (insurers, automotive and restraint systems manufacturers), and academia (The Center for Autonomic Computing (CAC) at The University of Florida and CChIPS). Continued work on this project will promote a more thorough understanding of opportunities for further advanced vehicle safety technology development. The cyberinfrastructure itself has potential commercial value because it can be adapted to support a variety of collaborative research and product development applications beyond pediatric motor vehicle crash injury prevention.

Research Experience for Teachers (RET)

With a Research Experience for Teachers (RET) supplemental opportunity grant from The National Science Foundation, CChIPS worked with Tim Callahan (pictured left), a teacher at Radnor Middle School in Radnor, PA, to develop educational materials to train public health advocates and teachers in sharing teen driver safety resources and knowledge with parents, teens, and others. The RET program supports the active involvement of K-12 teachers and community college faculty in scientific research to bring this knowledge and technological innovation into their classrooms. If you are interested in an RET position for next summer, please contact CIRP's Director of Training, Dr. Meghan Marsac, at marsac@email.chop.edu.

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 Philadelphia, in spring (to select the research portfolio for the upcoming year and to hear results from projects funded in the previous year) and in 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, investigators present their research proposals to the full IAB and then, in a closed door 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. This synergistic relationship helps ensure that the Center's research findings will have relevance to member companies and will be translated into injury prevention solutions to save children's lives.

Every membership dollar goes toward research. 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 organizations concerned with child safety, the Center has conducted specific research projects with major equipment manufacturers, restraint suppliers, insurance providers, and government agencies.

2009-2010 IAB Member Companies included:

- Britax Child Safety Inc.
- Dorel Juvenile Group Inc.
- Evenflo Inc.
- General Motors Holdings LLC
- Honda R&D Americas Inc.
- National Highway Traffic Safety Administration
- Nissan Technical Center North America Inc.
- Realtime Technologies Inc.
- State Farm Insurance Companies
- TK Holdings Inc. (Takata)
- Toyota Motor Manufacturing of North America
- Volkswagen Group of America Inc.

Center for Child Injury Prevention Studies

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On behalf of the children we work to protect, 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 collaborators. These research institutions not only waive their overhead fees, but also provide CChIPS with forward-thinking scientists committed to making the world a safer place for children and adolescents. Many thanks to The University of Pennsylvania, The University of Alabama, and The University of Florida.

The Ohio State University Medical Center

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