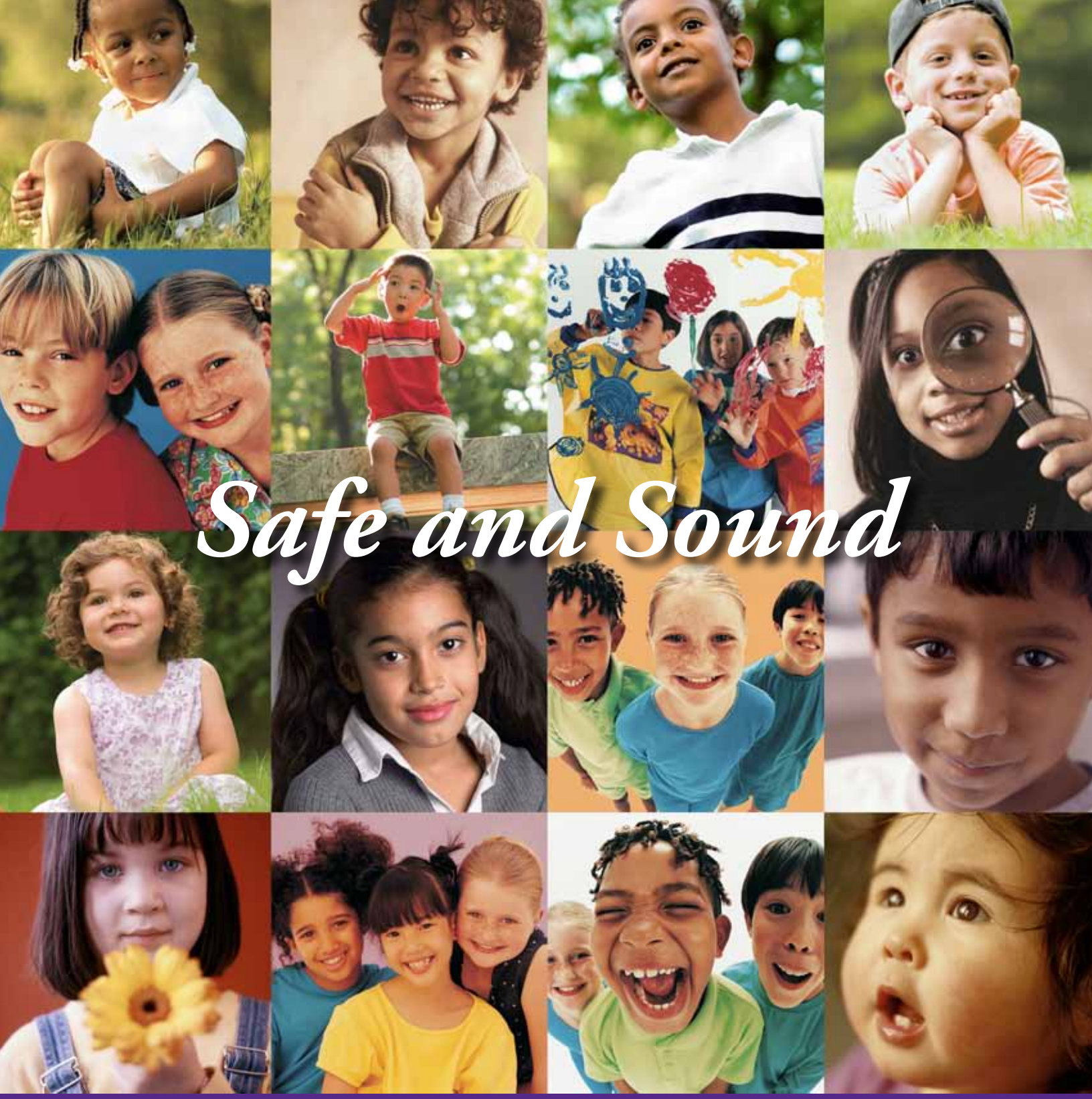


Safe and Sound

The Center for Child Injury Prevention Studies 2009 Annual Report

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

Partnering for Safety

A MESSAGE FROM THE CO-DIRECTORS

Safe and sound. That's what parents hope for and our Center works toward. In fact, the future is bright for continuing to advance 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 2009. Through a unique partnership with our Industry Advisory Board (IAB), our researchers are pinpointing and assessing the causes of injuries to children, youths, and young adults. With this knowledge, they are working to develop solutions to prevent these injuries from reoccurring. We are thrilled to share the highlights of this research in this report.

Founded in March 2005 with a grant from the National Science Foundation (NSF), CChIPS is one of more than 40 Industry/University Cooperative Research Centers funded by NSF in the country and the only one focused on child and young adult injury prevention. Besides publishing and disseminating our findings to further child safety, we also help students reach their full academic potential. By participating in our industry-approved research with guidance from our scientists, they are well prepared to pursue a career in pediatric injury prevention.

This annual report is intended to be shared with our collaborators, students, industry partners, and others with a stake in pediatric injury prevention. Our important work would not be possible without the insight, support, and mentorship of our IAB members. We are honored to have been given the opportunity to make the world a safer place for children, youths, and young adults. The work achieved in 2009 was substantial, and we are poised to expand with new industry partners and areas of research in the near future.

At the beginning of a new decade, the call to action continues. Through innovative research and outreach, we can prevent a greater number of injuries to children, youth, and young adults. The success of CChIPS, as explored in this report, illustrates the great impact industry and academia can achieve when working side by side. It's a testament to the unique center we have created with our industry partners who, like us, are dedicated to the common cause of protecting children. We look forward to sharing many more achievements with you in the years to come.

Flaura Winston, M.D., Ph.D., and **Sriram Balasubramanian, Ph.D.**, co-directors, CChIPS

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 country, CChIPS takes a unique approach to child safety research. Investigators from The Children's Hospital of Philadelphia (CHOP) and the University of Pennsylvania (UPenn) 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 primary cause 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 37 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 the broad and diverse backgrounds of its investigators to the creation and implementation of novel integrated approaches. For example, 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, all 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:

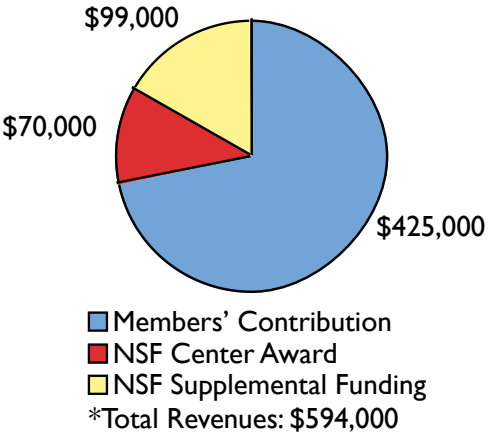
- Injury biomechanics, mechanisms, and tolerance
- Technological solutions to injury (design, development, and testing)
- Human interaction and behavior in relation to safety technology
- Safety promotion and education
- Safety device evaluation and behavior modification programs

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 Felicia Rowe, CChIPS coordinator, at rowef@email.chop.edu.

Funding the Research

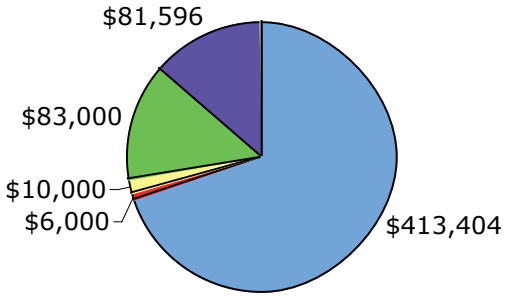
The Center for Child Injury Prevention Studies (CChIPS) is made possible through a grant from the National Science Foundation (NSF) and annual membership fees from its IAB member companies, comprised of industry and federal agencies that engage in scientific research and development to improve child safety. Each IAB member contributes $50,000 yearly to support the CChIPS mission. Beginning in 2010, affiliate memberships are available for small business at a reduced annual fee. These memberships are designed to boost small business involvement in the CChIPS mission and to encourage innovation. To become a member or to sponsor research with CChIPS investigators, contact Felicia Rowe, CChIPS coordinator, at rowef@email.chop.edu.

REVENUE



*Total Revenues: $594,000

EXPENDITURES



*Total Expenses: $594,000

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

Research In Action: 2008-2009 Project Highlights

Cervical Range of Motion of Children and Adult Volunteers

Principal Investigator:
Matthew R. Maltese, M.S., director of Biomechanics Research, Department of Anesthesiology and Critical Care Medicine at CHOP.

IAB Mentors:
Steve Ridella and **Rodney Rudd**, NHTSA, and **Steve Rouhanna**, Ford Motor Co., and **Uwe Meissner**, Volkswagen Group of America Inc.

Although pediatric anthropomorphic test devices (ATDs), also known as child crash test dummies, have provided invaluable data to guide the design of automotive safety systems, they are basically smaller versions of adult-sized dummies because child-specific data are not available. Since children are not small adults, the accuracy of child ATD data is limited. Therefore, there is an urgent need to collect child-specific biomechanical data and to improve pediatric ATDs, taking into consideration the profound soft tissue and bone structure changes that occur from birth through young adulthood.

As children grow, the spine undergoes changes to its structure that likely lead to differences in flexibility and overall head movement compared to adults. The "biofidelity" of the neck, in particular, is important because it governs the response of the head, the most frequently injured body region for children in motor vehicle crashes. This study is part of a focus of research at CChIPS that seeks to quantify how the spine bends in response to passive muscle forces using both pediatric and adult volunteers. These findings are being used by CChIPS researchers and others to develop the next generation of pediatric ATDs and computer models to reduce child injury and death from motor vehicle crashes.

During the study, volunteers were placed in passenger restraints and asked to flex their neck while relaxing the muscles surrounding it. Using surface electromyography (EMG) with audio feedback to ensure the neck muscles were relaxed, the researchers tracked the motion of the head and neck using a multi-camera 3-D target tracking system and calculated the neck flexion angle. Findings showed that the neck flexion angle significantly decreased with age and that females tend to have more spinal flexion than males. These results highlight the importance of age and gender in the development of population-specific crash test dummies and point to needed child ATD design changes.

Effect of Seat and Seat Belt Geometry on Abdominal Injuries in Belt-Restrained Children

Principal Investigator:
Kristy Arbogast, Ph.D., director, Engineering Core, Center for Injury Research and Prevention at CHOP and research assistant professor of Pediatrics, University of Pennsylvania.

IAB Mentors:
Steve Rouhana, Ford Motor Co., and **Uwe Meissner**, Volkswagen Group of America Inc.

Injuries to the abdomen are the second most common injury sustained by children restrained in seat belts. Current pediatric ATDs do not have the ability to detect injuries to this body region. This study builds on previous research conducted by CChIPS investigators that identified risk factors and causes for abdominal injury suffered by children in real world crashes to help develop accurate pediatric ATDs for improved child safety.

Using Partners for Child Passenger Safety (PCPS) data, the researchers developed a time-efficient method to quantify seat and seat belt geometry in the rear seats of actual vehicles with passengers ages 4 to 12 involved in frontal crashes. Using multivariate logistic regression, they related the geometrical measures to the occurrence of abdominal injury in the PCPS dataset. After adjusting for age and crash severity, the researchers found that certain seat and seat belt geometries are associated with increased risk of injury in rear seat-belted children. Most of these types of injuries involve the seat belt directly compressing the abdomen's internal organs, such as the liver or spleen. This can occur in several ways, such as when a child is seated in a rear seat belt system that places the lap belt high on the abdomen even when both the lap and shoulder belts are used and the child remains seated against the seat back. Other scenarios may involve a child placing the shoulder belt behind his back, resulting in geometry that may move the lap belt higher on the abdomen, and when a child scoots forward on the soft, compressible seat cushion before a crash, creating a more horizontal lap belt angle worsened by her moving forward and downward during the crash.

CChIPS members and other auto safety researchers are using these findings to inform car and child safety restraint product development for improved child safety.

Understanding and Optimizing the Advanced Restraint Systems for Rear-Seated Occupants Using MADYMO and ModeFRONTIER

Principal Investigator:
Yoganand Ghati, M.S., the Center for Injury Research and Prevention at CHOP.

IAB Mentors:
John Combest, Nissan, and **Hiromasa Tanji**, TK Holdings Inc.

This study builds upon findings from a previous CChIPS study that analyzed New Car Assessment Program (NCAP) data for various vehicles over model years and showed that the magnitude of the accelerations experienced by rear-seated occupants increased as the cars got newer. At the same time, these newer vehicles received a better NCAP star rating, which is based on the driver and right front-seated passenger risk of injury, indicating improved protection over older cars. Better star ratings, despite higher accelerations, are primarily due to better restraints (advanced air bags, seat belts with pretensioners and load limiters) available to passengers in the front seat but not in the back seat.

The rear-seated occupant population is diverse and consists of children and older adults who may have different injury risks than typical front seat occupants. The diversity of rear seat occupants' size and age and associated injury tolerance limits make it more challenging to design and optimize restraint systems for rear-seated occupants. This study was designed to evaluate and optimize advanced restraint systems, such as those used in the front seat, for different-sized anthropomorphic test devices (ATDs) in typical vehicle rear-seat conditions using computational modeling techniques.

Baseline computational models of rear-seated occupants of different age groups using advanced restraint systems (pretensioners and load limiters) with typical vehicle interiors were created using MADYMO. The effect of variations in vehicle and restraint parameters — such as seat buckle height, seat cushion ramp height, and shoulder belt anchor locations — on injury metrics and occupant kinematics were assessed. Results showed that the use of a load limiter and retractor pretensioner has the highest effect on injury metrics and ATD kinematics, while the buckle pretensioner's effect is negligible for all ATDs. The D-ring, belt buckle, and seat cushion ramp were not found to be as significant for optimizing safety.

These findings suggest that while designing vehicles for the optimum safety of rear-seated occupants, careful consideration should be given to the load limiter level and the use of the retractor pretensioner. Technologies implemented in the front seat may not be exactly transferable to the rear seat due to different occupant sizes.

State-of-the-Art Science: An Update on Child and Adolescent Injury Research and Prevention

Principal Investigator:
Yoganand Ghati, M.S., the Center for Injury Research and Prevention at CHOP.

IAB Mentor:
Louis Brown, Volkswagen Group of America Inc.

State-of-the-art information on child and adolescent injury prevention is a vital resource for furthering the science and development of effective safety technologies. This knowledge is important not only to successfully complete research projects, but also to help researchers, manufacturers, and policymakers make sound decisions about the direction of future projects and initiatives. Unfortunately, this information is not readily available in one place. Articles on child and adolescent injury prevention are published annually in scientific journals, scientific books, proceedings from conferences, magazines, newspapers, and on websites of research institutions and outreach groups. This myriad of sources makes it difficult for those with a stake in child injury prevention to stay up-to-date on current research, outreach, and legislature activities.

To bridge this gap, a key benefit of CChIPS membership is access to our state-of-the-art science library. Summarized monthly with updates on developments in the field of pediatric injury prevention, this handy resource organizes the latest research papers by topic, which include: biomechanical research; anthropomorphic test dummies and computational models; sports and recreation injuries; teen driving; and child safety seats. Links are provided to article abstracts, and the full paper is retrieved upon request.

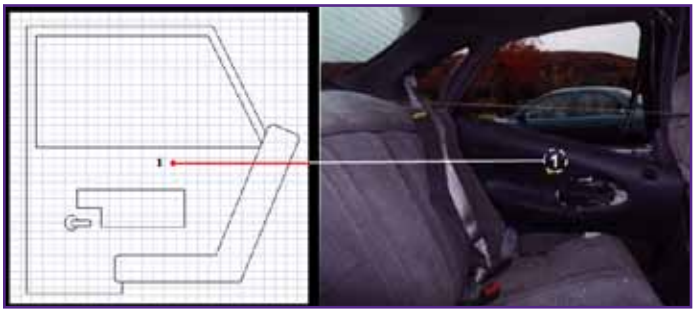
The library also includes information gleaned from ongoing review of The Federal Register for government rules and proposed rules applicable to injury prevention, as well as a list of upcoming conferences with content relevant to biomechanics, injury prevention, and vehicle safety.

This summary of research, outreach, and government efforts offers a glimpse of the current state of child and adolescent injury prevention and serves as an excellent starting point for CChIPS scientists and members wishing to stay up-to-date in their field of interest. The state-of-the-art science library is a helpful resource to improve research efforts and to develop unique, novel, and/or effective products and interventions in child and adolescent safety.

Child Restraint Systems in Side Impact Crashes: Injury Patterns and Causation

Principal Investigator:
Kristy Arbogast, Ph.D., director, Engineering Core, Center for Injury Research and Prevention at CHOP and research assistant professor of Pediatrics, University of Pennsylvania.

IAB Mentor:
Steve Ridella, NHTSA.



Side-impact crashes pose a significant risk to motor vehicle occupants. Although European data have shown that these crashes only comprise 25 percent of all vehicle collisions, the injuries sustained due to them represent 40 percent of all motor vehicle injury costs. The risk of injury is especially high for vulnerable occupants such as children, who are often seated in the rear of vehicles. Analyses of the U.S. Fatal Analysis Reporting System (FARS) show that 42 percent of fatalities of rear-seated children ages 0 to 8 occurred in side-impact crashes.

While previous research has defined the risk of injury or described what body regions are typically injured, preventing these injuries was not possible because we did not know specific injury mechanisms. This study was designed to begin answering this question.

The researchers indentified the causes of clinically significant injury (an injury which scored 2 or greater on the Abbreviated Injury Scale) in children seated in a rear-facing CSS, forward-facing CSS, or booster, all in the rear of vehicles. The multidisciplinary team of physicians and engineers reviewed 41 case studies from the Crash Injury Research and Engineering Network (CIREN) and Partners for Child Passenger Safety (PCPS) databases to determine how the injuries occurred and what vehicle components may have directly or indirectly contributed. Probable contact points were transferred to generic vehicle interior diagrams to provide a visual representation of interactions that may cause injury.

The researchers found that the most common injuries occurred to the skull and brain, with a growing proportion of fractures to the skull occuring with increased child age. The children also suffered several lung contusions but no rib fractures, noticeably different than the experience of adult crash victims who commonly fracture their ribs in similar crashes. Occupants seated on the side of the impact ("near-side") typically experienced head and face contact along the rear vertical plane of the window and the horizontal plane of the windowsill. Occupants seated in the center or side of the vehicle away from the crash ("far-side") typically experienced impact along the edges of the front seat back and front seat head restraint closest to the side of the crash.

A growing body of research is investigating ways to prevent head injury in children in child-restrained systems who were passengers in side impact crashes. This study adds to this useful knowledge to help scientists and industry develop both educational and technological interventions to reduce the burden of injury to restrained children in side impact crashes.

Painful Spine Injury in Children and Young Adults: Integrated Biomechanics and Pain Modeling

Principal Investigator:
Beth Winkelstein, Ph.D., assistant professor of Bioengineering and director of the Spine Pain Research Laboratory at the University of Pennsylvania.

IAB Mentors:
Christina Mullen, Toyota Motor North America Inc., and
Rodney Rudd, NHTSA.

There is mounting evidence that biomechanics and age modulate both pain symptoms and why pain may persist. For example, in some people repeated pain from an acute injury changes the way the brain reacts. Even after the injury has healed, pain messages replay over and over again. Little, however, is known about the mechanisms for differences in the pain response, including children that suffer painful spinal injuries.

Using integrated biomechanical and pain modeling methods, researchers conducted this study to find out if pain from spinal injury is age-dependent. They expanded on an in vivo model of spinal facet-mediated painful injury to provide injury data for children and young adults to evaluate the role of age in painful neck injuries, as well as whether and how the tolerances and mechanisms for this class of injuries are altered in populations of different ages.

The investigators used in vivo models because computer modeling and research on cadavers have limitations. "Computer and cadaver modeling can only suggest and conjecture," explains Dr. Winkelstein. "Until we translate the research into physical and chemical responses, we won't know exactly what's going on. You can't treat a cadaver."

This CChIPS study adds to Dr. Winkelstein's body of work to help scientists better understand the body's response to pain in order to determine optimum treatment. This research significantly adds to a relatively limited knowledge of these crucial areas in the field.

Learn more about our published findings at www.chop.edu/cchips.

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 and IAB members and rigorous and 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, with one initiated and led by a student (See *Relations Between Executive Function and Pedestrian Injury Risk in Children With and Without ADHD* on page 6.) To date, over 30 students have assisted in CChIPS research projects.

Supplemental Research Funding

With a grant from the NSF, CChIPS also engages in other research projects with university research centers across the country. In 2008-2009, these projects included:

- ***Transforming Traffic Safety Through Autonomic Computing: Virtual Organization in Traffic Safety.*** This successful collaboration between Jose Fortez, Ph.D, the University of Florida; Dennis R. Durbin, M.D., co-scientific director of the Center for Injury Research and Prevention at CHOP and professor of Pediatrics at the University of Pennsylvania; and Flaura Winston, M,D., Ph.D., director of CChIPS, co-scientific director of the Center for Injury Research and Prevention at CHOP, and associate professor of Pediatrics at the University of Pennsylvania and NHTSA, conducted a planning study to create a Virtual Organization in Traffic Safety. Keyu Chen, a doctoral candidate at the University of Florida worked closely with the team to develop this innovative tool to improve child injury prevention. It will become 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.
- ***Relations Between Executive Function and Pedestrian Injury Risk in Children With and Without ADHD.*** This project was completed as part of Despina Stavrinos' doctoral dissertation in Psychology at the University of Alabama. The study explored the underlying mechanisms for pedestrian injury risk in children with Attention Deficit Hyperactivity Disorder-Combined Type (ADHD-C), a group at particular risk during adolescence. The findings revealed that these children tended to choose riskier ways to cross streets, gave little time to spare when crossing, and had many close calls with automobiles. Mediation analyses revealed that ADHD-associated deficits in executive function, which manages a person's decision-making and abstract thinking, is directly associated with increased pedestrian injury risk among young people with the condition.
- ***National Child Occupant Special Study (NCOSS).*** The goal of this study, led by Kristy Arbogast, Ph.D., director of Engineering for the Center of Injury Research and Prevention at CHOP, is to adapt the Partners for Child Passenger Safety (PCPS) data collection instrument 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.

Research Experience for Teachers (RET)

With a Research Experience for Teachers (RET) supplemental opportunity grant from NSF, CChIPS worked with Claire Edwards, a Philadelphia high school teacher, to help identify a Web-based, driver education and safety plan for reducing teen driver crashes. She also explored the development of driver safety-related service learning lesson plans. The RET Engineering program supports the active involvement of K-12 teachers and community college faculty in engineering research to bring this knowledge and technological innovation into their classrooms.

Synergy In Motion

Sponsoring industry members play an integral role in setting the research agenda for CChIPS. These members comprise the Center's IAB. Membership is open to all companies 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 the spring (to select the research portfolio for the upcoming year and to learn about project results from the previous year) and in the fall (to review progress, provide insights to the current year's research portfolio, and select ideas for the next year's proposal submissions). After a formal process of proposal submissions that involves extensive discussions with chosen IAB mentors during the spring meeting, investigators present their research proposals to the full IAB. The board then votes on the proposals, ranking them based on points allotted, during a closed door meeting.

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 and prevent injuries.

Every membership dollar goes toward research. The CHOP Research Institute, the University of Pennsylvania, and other research facilities involved in CChIPS projects waive overhead fees to make this vital work possible. IAB members also can rely on CChIPS's 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 original equipment manufacturers, restraint suppliers, insurance providers, and government agencies.

2008-2009 IAB Member Companies included:

- Britax Child Safety Inc. *
- Dorel Juvenile Group Inc.
- Ford Motor Company
- Honda R&D Americas Inc. (since April 2009)
- The National Highway Traffic Safety Administration (NHTSA)
- Nissan Technical Center North America Inc. *
- State Farm Insurance Companies® *
- TK Holdings Inc. *
- Toyota Motor North America Inc. *
- Volkswagen Group of America Inc. *

* *Founding Member*

The Center for Child Injury Prevention Studies (CChIPS) and the children we work to protect 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 Drexel University, Duke University, Monash University, Ohio State University, Rowan University, Wichita State University, the University of Alabama, the University of Florida, the University of Massachusetts, and the University of Michigan.

Center for Child Injury Prevention Studies

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