Published in: Proceedings of the 11th International Forum of Automotive Traffic Safety, 2014, pp. 11-13
No. ATS.S3B1-02

Safety for Children in the Rear Seat – A review of the progress at the SAFER Centre

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ABSTRACT

Background: In developed countries, fatalities and severe injuries to child occupants in motor vehicle crashes have decreased over the years. In Sweden, the number of fatally injured children of ages 0-14 years has decreased from an average of 26 fatalities annually in the 1980s to an average of 4 fatalities annually in the early 2000s (Carlsson et al. 2013). Never the less traffic accidents remain the leading cause of death to children in Sweden, and of all the child (age 0-17) fatalities due to accidents during 1993-2003, 214 (64%) were due to road traffic injuries (Trafikverket, 2013). A review of Stockman et al. (2013a) indicate that children aged 4 to 12 represent one third of occupants in the rear seat in the United States and of all children aged 4 to 12, approximately 67 percent were seated in the rear seat of passenger vehicles or light truck vehicles.

Objective: This paper is a condensed review of the child occupant safety research that has been carried out in recent years at the SAFER Vehicle and Traffic Safety Centre in Göteborg, Sweden. The overall aim of this work at SAFER has been to address the safety of forward facing child occupants (aged 3-12) in the rear seat during collisions ranging from frontal, frontal oblique to side impacts. A more detailed description of the project, as well as a status report was published by Jakobsson et al. (2011).

Methods and Results: The child safety research at SAFER is a broad comprehensive research effort combining expertise from industry and academia and using various applied research methodologies directed toward countermeasures. This includes real world crash data analysis, real world on-road driving studies and maneuver studies, crash testing and simulations.

- A study of child car occupant fatalities in Sweden (Carlsson et al. 2013) reviewed accident data of all fatally injured 0-14 year old car occupants in Sweden during the years 1956-2011. The 83% reduction in fatalities from the period 1960s-1980s to the 2000s was the combined result of the increased use of child restraint systems, implementation of new vehicle safety technologies and improved crashworthiness, and general improvements in the road infrastructure. Frontal and side collisions were the most common crash situations in fatal crashes involving one other vehicle, and for restrained children head injuries caused more than half of the fatalities.
- Insurance data including reported car crashes from 1998 to 2010, with at least one injured child 0–12 years of age, were obtained including 2619 injured children with 3704 reported medical diagnoses (Bohman et al. 2014). In all, 55 children sustained injuries resulting in permanent medical impairment (PMI) of which 75 percent were at AIS 1 or AIS 2 level. The head and cervical spine were the body regions sustaining the most injuries resulting in PMI. Sixty-eight percent of all injuries resulting in PMI were AIS 1 injuries to the cervical spine, with the majority occurring in frontal or rear impacts. The head was the second most commonly injured body region with injuries resulting in PMI (12/59), which were predominantly AIS 2+. In addition, mild traumatic brain injuries at AIS 1 level were

found to lead to PMI.
- Bohman et al. (2011a) identified impact by the head to the back of the front seat as a predominant cause of injury for rear-seated, seat belt-restrained children aged 3–13 who had sustained AIS 2+ head injuries in frontal impacts. The study highlighted vehicle maneuvers, prior to impact, as a contributing factor for such head injuries. Occupant motion, prior to impact, placed the occupant in a suboptimal restraint condition, allowing the head to contact with the side interior and the back of the front seat.
- Stockman et al. (2013a) studied the kinematic response of children and child anthropomorphic test devices (ATDs) during emergency braking events in different restraint configurations in a passenger vehicle. Children aged 4 to 12 years old were included as well as four ATD types. The test subjects were placed on the right rear seat of a modern passenger vehicle. Child volunteers had greater maximum forward displacement of the head and greater head rotation compared to the ATDs. The average maximum displacement for children ranged from 165 to 210 mm and 155 to 195 mm for the forehead and ear target, respectively. Corresponding values for the ATDs were 55 to 165 mm and 50 to 160 mm. The change in head angle was greater for short children than for tall children. It was concluded that forward displacement was within the same range for all children regardless of stature and restraint system. However, the maximum forward position depended on the initial seated posture and shoulder belt position. Shorter children exhibited a greater flexion motion of the head.
- Stockman et al. (2013b) studied the kinematics and shoulder belt position of child anthropomorphic test devices (ATDs) during emergency steering maneuvers and compared to the results from child volunteers (Bohman et al. 2011b). The question regarding which ATD replicates better the behavior of children exposed to steering maneuvers remained open, partly depending on what phase of the maneuver is of interest. The study revealed limitations in the ability of the different ATDs in replicating potential pre-crash posture and motion of children as a result of vehicle emergency steering maneuvers.
- All standardized child safety crash testing is carried out with the ATD positioned in a pre-defined neutral upright-seated posture. Our studies mentioned above indicate that in real world car collisions, children can be moved away from the standardized position as a result of pre-crash maneuvers such as emergency braking or steering. Brolin et al. (2014) pointed to the potential of advanced restraint systems to account for these pre-crash occupant motions. In addition they put focus on the potential of numerical human body models (HBMs) of various pediatric sizes. These HBMs are expected to be able to also replicate the child motion and posture change during pre-collision maneuvers and thus become an important tool in the development and evaluation of advanced restraint systems.

Conclusions: Fatalities and severe injuries to child occupants in motor vehicle crashes have decreased over the years in countries where the use of child restraints have become mandatory. Never the less traffic accidents remain a leading cause of death to children. The head and cervical spine were the body regions sustaining the most injuries resulting in PMI. Pre-crash braking or steering maneuvers might move children into a posture that the restraint systems have not been evaluated for. Numerical human body models will become an important tool in the development of advanced restraint systems.

References:

Bohman K, Arbogast KB, Bostrom O. Head injury causation scenarios for belted, rear-seated children in frontal impact. Traffic Injury Prev. 2011a;12:62-70

Bohman K, Stockman I, Jakobsson L, Osvalder AL, Bostrom O, Arbogast KB. Kinematics and shoulder belt position of child rear seat passengers during vehicle maneuvers. Ann Adv Automot Med. 2011b;55:15-26

Bohman K., Stigson H., Krafft M. Long-term medical consequences for child occupants 0-12 years injured in car crashes.

Traffic Injury Prevention (2014) 15, 370–378

Brolin K, Stockman I, Andersson M, Bohman K, Gras L-L, Jakobsson L. Safety of children in cars: A review of biomechanical aspects and human body models. IATSS Research (2014)

Carlsson, A., Strandroth, J., Bohman K., Stockman I., Svensson M., Wenäll J., Gummesson M., Turbell T., Jakobsson L. Swedish Child car passenger fatalities in Sweden during six decades. IRCOBI, 2013

Jakobsson L, Bohman K, Andersson M, Stockman I, Boström O, Svensson M, Svanberg H, Wimmerstedt M, Arbogast KB. Rear Seat Safety In Frontal To Side Impacts – Focusing On Occupants From 3yrs To Small Adults. The 22nd International Technical Conference on the Enhanced Safety of Vehicles (ESV) Washington, D.C., June 13-16, 2011 , Paper Number 11-0257

Stockman I., Bohman K., Jakobsson L., Brolin, K. Kinematics of Child Volunteers and Child Anthropomorphic Test Devices During Emergency Braking Events in Real Car Environment. Traffic Injury Prevention (2013a) 14, 92–102

Stockman I, Bohman K, Jakobsson L. Kinematics and shoulder belt position of child anthropomorphic test devices during steering maneuvers. Traffic Inj Prev. (2013b) 14, 797-806.

Trafikverket. http://www.trafikverket.se/Privat/Trafiksakerhet/Barn-i-trafiken/Barn-och-ungdomvag/Fakta-om-barn-och-trafik/Nationell-statistik-over-omkomna-barn/ Retrieved 5 of February 2013.

Keywords: Child safety, Child restraint, Vehicle traffic accident, Injury analysis