

Table 2: Summary of the literature on automobile restraints for children

First author	Date	Design	Population	Data source	Key outcomes	Reference no.
Seating position and restraint effectiveness						
Berg	2000	Case-control study	Utah children ≤ 14 yrs	Statewide crash database probabilistically linked to hospital records	Odds of injury 1.7 times higher in front seat than in rear seat; odds of injury 2.7 times higher for unrestrained children than for restrained children	16
Braver	1998	Cohort study	US children ≤ 12 yrs in fatal car crashes	Fatal Accident Reporting System,* data for 1988 to 1995	36% reduction in risk of fatality for children in rear seat compared with front seat	15
Isaksson-Hellman	1997	Cohort study	Swedish children ≤ 15 yrs	Database of 25 000 property damage crashes (1976 to 1996) investigated by Volvo, subset of 4242 children	Restraint effectiveness 96% for rear-facing child restraint system, 77% for booster and 59% for seat belt	18
Miller	1993	Cost-benefit study	US children	Published estimates	\$1 spent on child seat saves \$2 in medical care costs, \$6 in tangible expenses and \$25 in terms of quality of life (based on insurance payouts for pain and suffering)	19
Kahane	1986	Retrospective, mixed design	US children	National Accident Sampling System	Child restraints reduce risk of fatality by 71% and risk of serious injury by 67%	17
Restraint use rates						
Agran	1998	Cohort study	US children in fatal car crashes	Fatal Accident Reporting System,* data for 1994	Only 56% of children were restrained; best predictor of child restraint was driver's use of restraints	2
Transport Canada	1997	Cross-sectional survey	Canadian children	Survey on use of child restraints in Canada	Restraint rates: 96% for infants, 91% for 1- to 4-year-olds and 85% for 5- to 15-year-olds	20
Campbell	1997	Cross-sectional survey	Children in Fife, Scotland		Restraint rates: 70% for infants, 79% for 1- to 4-year-olds and 57% for 5- to 15-year-olds	55
US Dept. Transport	1996	Cross-sectional survey	US children	National Occupant Protection Use Survey, 1996	Restraint rates: 85% for infants, 60% for 1- to 4-year-olds and 65% for 5- to 15-year-olds	21
Restraint misuse rates						
Auger	1999	Cross-sectional survey	Child passengers in daycare parking lots in Quebec	Not specified	62% of infant seats, 59% of forward-facing child seats and 33% of booster seats used incorrectly	5

Table 2: Summary of the literature on automobile restraints for children

First author	Date	Design	Population	Data source	Key outcomes	Reference no.
Eby	1999	Cross-sectional survey	Child passengers in daycare and pediatric clinic parking lots in Michigan	1258 child passengers, 87 seat inspections	Major misuse in 25% and moderate misuse in 63% of seats inspected	8
Decina	1997	Cross-sectional survey	Child passengers in shopping mall parking lots in 4 states	5900 child passengers	79% of infants, 81% of toddlers and 50% of preschoolers restrained incorrectly	7
Campbell	1997	Cross-sectional survey	Child passengers in car parks in Fife, Scotland	596 occupants in 180 cars	44% of rear-facing seats and 60% of forward-facing seats used incorrectly	6
Margolis	1992	Cross-sectional survey	Child passengers in fast food parking lots in Michigan	717 child passengers	63% of child restraint devices used incorrectly	9
Age for forward-facing seating						
Weber	2000	Literature review			No reports of cervical cord trauma in rear-facing children	24
Multiple authors		Case reports and small case series	Injured children admitted to hospitals		Catastrophic neck injuries in forward-facing children with either lap or lap and shoulder restraints	26–31, 56–58
Premature graduation						
Ramsey	2000	Cross-sectional survey	Random sample of daycare centres in King County, Wash.	149 children	28% of 4-year-olds, 36% of 5-year-olds and 70% of 6- to 8-year-olds used lap shoulder belts without booster seats	32
Winston	2000	Prospective cohort study	Child passengers insured by a single provider in the United States	Stratified sample of all property damage crashes involving a child passenger	Children age 2 to 5 yrs who crashed while wearing a seat belt had a relative risk of significant injury of 3.5 (95% CI 2.4–4.2) and a relative risk of significant head injury of 4.2 (95% CI 2.6–6.7) compared with children restrained in the correct device	10
Decina	1997	Cross-sectional survey	Child passengers in shopping mall parking lots in 4 states	5900 child passengers	21% of toddlers 9–18 kg and 75% of preschoolers 18–27 kg restrained in seat belt only	7
Lap belt injuries						
Sturm	1995	Case series	Child passengers age 3–15 yrs with lumbar compression fractures	7 medical records at a children's hospital in Washington, DC	Lumbar compression fractures (anterior) occurred in association with lap belt injuries	39

Table 2: Summary of the literature on automobile restraints for children

First author	Date	Design	Population	Data source	Key outcomes	Reference no.
Rumball	1992	Case series	Child passengers age 3–17 yrs with lumbar flexion–distraction fractures	18 medical records at an Ontario children's hospital	Diagnostic delay in 5 cases, paraplegia in 3 cases	37
Glassman	1992	Case series	Child passengers ≤ 16 yrs	12 medical records at a Kentucky children's hospital	Brace treatment successful for bony chance fractures; brace or operative treatment used for ligamentous injuries	35
Anderson	1991	Retrospective cohort study	Adult and child patients with spinal or abdominal injuries after motor vehicle crashes	Trauma registry, Seattle, WA	Lumbar chance fracture strongly associated with rear seating position, lap belt and presence of hollow viscus injury	33
Reid	1990	Case series	Child passengers age 7–17 yrs with lumbar flexion–distraction fractures	7 medical records at a Manitoba children's hospital	Fractures associated with lap belt bruise on abdomen and with hollow viscus injuries	38
LeGay	1990	Case series	Child and adult passengers with lumbar flexion–distraction fractures	18 medical records at a Nova Scotia hospital	12 of 18 patients had intra-abdominal injury; diagnosis delayed in 3 patients, including 1 patient with spinal fracture	36
Garrett	1962	Observational study	US drivers and passengers	2778 crash and medical records from 22 states	First description of lumbar and intra-abdominal injuries related to seat belt use	34
Ejections						
Scheidler	2000	Cohort study	Injured child passengers ≤ 16 yrs admitted to Pennsylvania trauma centres	Pennsylvania Trauma Outcome Study database	88% of ejected child occupants were unrestrained; ejection tripled mortality risk	40
Esterlitz	1989	Double-pair comparison study	Adults in fatal crashes in the United States	Fatal Accident Reporting System, 1982 to 1986*	8-fold increase in fatality risk if ejected	42
Side impacts						
Arbogast	2001	Prospective cohort study	Child passengers insured by a single provider in the US	Stratified sample of all property damage crashes with a child passenger	Children on struck or nonstruck sides suffered head injuries; little protective effect of restraints was noted	44
Braver	1998	Cohort study	US children in fatal car crashes	Fatal Accident Reporting System, data for 1988 to 1995*	Child fatality rate of 30% for side impacts and 17% for frontal impacts	15
Agran	1989	Cohort study	Injured child passengers age 4–9 yrs	700 cases from 9 emergency rooms and coroner's office in Orange County, Calif.	Significant injuries in 41% of side impacts, 15% of frontal impacts and 3% of rear impacts	43

Table 2: Summary of the literature on automobile restraints for children

First author	Date	Design	Population	Data source	Key outcomes	Reference no.
Air bag injuries						
Tylko	2001	Mechanical test	Child-size crash dummies	Staged collisions	Out-of-position child occupants at risk of injury from front- or rear-seat side air bags; correctly restrained child occupants in the same positions were not at risk	51
Mehlman	2000	Case report	4-year-old child	Medical records	Severe brachial plexus injury and upper extremity fracture secondary to air bag deployment	48
German	1998	Case report	4-year-old child	Medical records, collision investigation and reconstruction of crash with instrumented child dummies	Severity of injury very sensitive to precrash position of dummy	46
Hollands	1996	Case report	3-year-old child	Medical records and collision investigation	Child in forward-facing seat in front of passenger air bag sustained severe head injury	47
Willis	1996	Case report	5-year-old child	Medical records	Fatal hyperextension neck injury in a low-speed crash	49
<i>MMWR</i>	1996	Case series	US children	Fatal air bag crashes in the United States reported to NHTSA (1993 to 1996)	32 child air bag fatalities, 21 involving children unrestrained or incorrectly restrained, 9 involving children in rear-facing child-safety seats in the front passenger seat	50

Note: CI = confidence interval, NHTSA = National Highway Traffic Safety Administration.
*US database that includes all fatal crashes in population.

References

55. Campbell H, MacDonald S. Many children remain unrestrained in cars [letter]. *BMJ* 1997;314(7092):1483.
56. Taylor TKF, Nade S, Bannister JH. Seat belt fractures of the cervical spine. *J Bone Joint Surg Br* 1976;58(3):328-31.
57. Odent T, Langlais J, Glorion C, Kassis B, Bataille J, Pouliquen J. Fractures of the odontoid process: a report of 15 cases in children younger than 6 years. *J Pediatr Orthop* 1999;19:51-4.
58. Lynch JM, Meza MP, Pollack IF, Adelson PD. Direct injury to the cervical spine of a child by a lap-shoulder belt resulting in quadriplegia: case report. *J Trauma* 1996;41(4):747-9.