

## ***Positive trend of proper restraint usage – injury reduction for children aged 4-12***

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### **Introduction**

Although child restraint systems have high effectiveness, the maximum effect of a restraint system is not attained if the child is not using the optimal system for its size and age. For children aged 4 to 10 a belt-positioning booster seat or cushion is recommended and estimated to have an effectiveness of approximately 75% as compared to unrestrained and approximately 30% as compared to belted only (Jakobsson et al. 2007). Arbogast et al. (2009) found that children who were aged 4 to 8 and using boosters were 45% less likely to sustain injuries than similarly aged children who were using the belt only.

Belt-positioning booster cushions were introduced in the late 1970's (Norin et al. 1979). Today, there are three main belt-positioning boosters; booster cushions (backless), high-back boosters and integrated (built-in) boosters. The booster is used with the adult seat belt which restrains both the child and the booster. The integrated (built-in) boosters were developed in order to simplify usage and to minimize misuse (Lundell et al. 1991). They can be found in the rear seats of Volvo cars from 1991 onwards, in the mid-seat or outboard position (depending on car model) and always with 3-point seat belts and head restraints. In 2007, a 2-stage integrated booster was introduced to better accommodate the needs and protection of the growing child (Jakobsson et al. 2007). Together with the 2-stage integrated booster, the seat belt is equipped with a pretensioner and progressive load limiter adapted to the child to further enhance the crash performance. Also, the 2-stage booster cushion sets the child in improved protection position with regard to the side impact protection systems, such as the extended inflatable curtain. All this work as a system to increase safety by encouraging increased usage by a large cross-section of child occupant sizes together with a more adapted crash performance for the children.

Using Volvo's accident data, Isaksson-Hellman et al. (1997) estimated that the total injury reducing effect of MAIS2+ injuries would increase by 14 percentage points if all children were properly restrained by the recommended child restraint for their size and age. Even though 95 % of all children used restraints in the data, they were not all using the recommended system for their size and age, some children switched over earlier than recommended. A prediction of the optimal protection was compared to measured protection. More than ten years have now passed by and the present study follows up on this prediction.

The objective of the present study is to evaluate and discuss the booster usage focusing children aged 4 to 12.

### **Methods**

The same data base as in the study of Isaksson-Hellman et al. (1997) is used in the present study. A continuous collection of crash, vehicle and personal data (including injuries if any) of crashed Volvo cars in Sweden forms the Volvo Accident data base. The collection is based on a repair cost limit (currently 4500€) and contains almost 30,000 crashes since early 1970:

ies. The selection for the dataset in this study is children aged 4-12 involved in crashes during the years of 1987-2008, a total of 2626 children. Table 1 shows that the children are quite evenly distributed over age (10-12% in each age group) and 80% are seated in the rear seat. 1711 of the children were involved in crashes 1987-1997 and 915 during 1998-2008. The overall restraint use is high, less than 4% of the children are unrestrained.

Table 1. Amount of children in the dataset with respect to age and seating position

age(y)	rear seat	front seat	total
4	296	41	337
5	250	47	297
6	238	36	274
7	213	39	252
8	222	47	269
9	211	63	274
10	256	83	339
11	199	83	282
12	221	81	302
<b>total</b>	<b>2106</b>	<b>520</b>	<b>2626</b>

## Results

Figure 1 shows booster usage rates for children involved in crashes 1987-1997 and 1998-2008. For all the children aged 4 to 12, the total increase of booster usage is 4%. Considering the children aged 4-10 which are recommended to use booster, the increase is as much as 10%. The increase is rather evenly distributed over age, up to 10 years old, with a high usage (approximately 80%) at age 5 dropping down to less than 10% for 11 years old children.

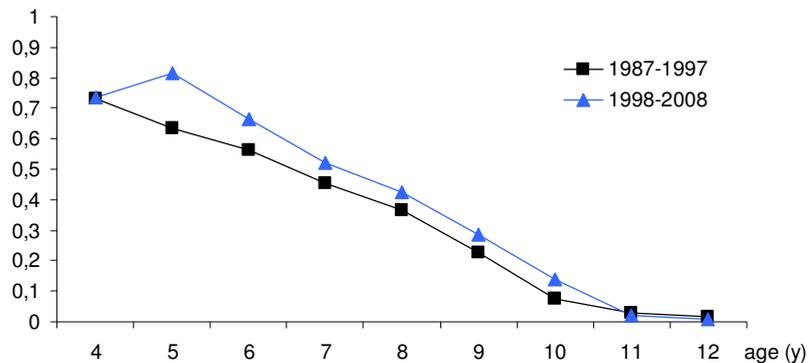


Figure 1. Booster usage rates versus age, comparing children involved in crashes 1987-1997 to 1998-2008.

For the same time period, the overall injury reduction of MAIS2+ injuries is more than 60% for children aged 4-12. Although several contributing factors, the increase of usage of age relevant restraints most likely contribute.

Among the booster types, high-back boosters, booster cushions and integrated (built-in) boosters are used. The amount of children using high-back boosters and booster cushions (including integrated boosters) per age group for the two subsets are shown in Fig. 2a and 2b.

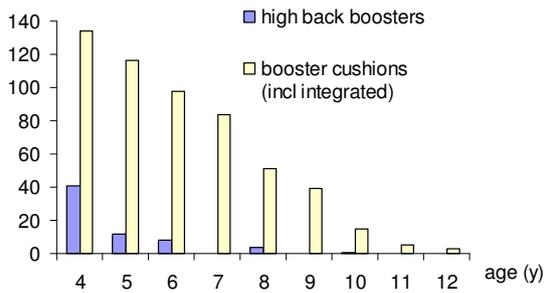


Figure 2a. Amount of children, per age group, using high back boosters and booster cushions (incl. integrated boosters) respectively, involved in crashes 1987-1997

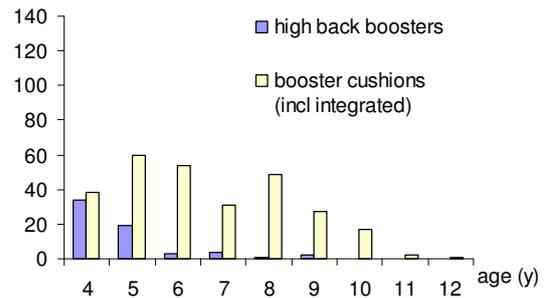


Figure 2b. Amount of children, per age group, using high back boosters and booster cushions (incl. integrated boosters) respectively, involved in crashes 1998-2008

Backless booster cushions are by far the most common booster type in this dataset (86% of all boosters), Figures 2a and 2b. The booster cushions are used over the whole age span decreasing over age, but decreasing less than the overall booster usage. More than 90% of all the high back boosters in the dataset are used by children below age 8. High-back boosters are proportionally more used in the more recent subset (Figure 2b), but still mainly in the lower age groups. Based on this data it is quite clear that the oldest children in the booster recommended age span to a greater extent use backless booster cushions.

Comparing accessory boosters to integrated (built-in) boosters, a trend of higher usage rate with increased age is seen for the integrated boosters. Figure 3 displays the distribution of accessory (including high-back and cushions) and integrated boosters over the age groups 4-12, involved in crashes 1998-2008, each booster category adding up to a total of 100%. Although only 10% of all the boosters in the subgroup are of integrated type, it is quite clear that they proportionally are used by more children in the higher age groups, up to 10 years old.

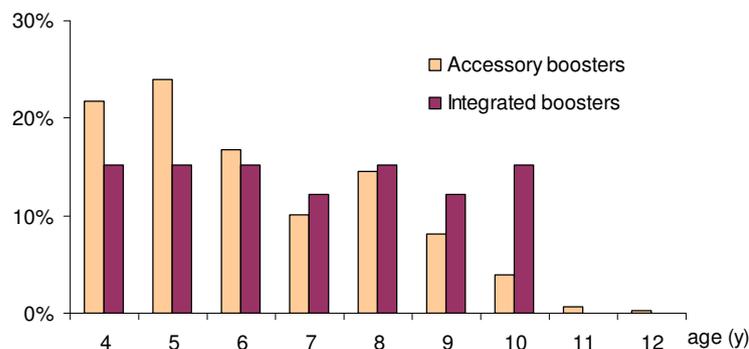


Figure 3. Distribution of booster types over age, comparing accessory boosters (incl. high-back and cushions) and integrated boosters involved in crashes 1998-2008.

## Discussions

Child restraint system usage is still an important issue and especially for the children in the older age range for boosters. Still there is a high injury reduction potential if all children aged 4-10 used boosters together with the seat belt. This study clearly indicates that there is a higher acceptance among the older range of the age group to use booster cushions as compared to high-back boosters. A booster cushion offers essential protection to a child in frontal impacts and puts the child into a better position and protection in a side impact (Jakobsson et al. 2005, Arbogast et al. 2009). The large injury reduction seen in the present study comparing the two decades can most probably to some extent be attributed the increase in booster usage for the age interval studied. Increasing the booster usage, high-back boosters as well as booster cushions, will improve safety for children overall. Studying children aged 4 to 8 restrained in boosters, Arbogast et al. (2009) found no evidence of difference in the safety performance of backless versus high-back boosters.

Figure 3 indicates that the acceptance of integrated boosters seems to be higher for the older children (8-10), as compared to accessory booster. In an attitude and handling focus group study, integrated boosters were perceived more acceptable as well as better with respect to correct usage as compared to accessory boosters (Bohman et al. 2007). Integrated boosters will most likely motivate usage for a group that today mostly are restrained by adult belt only. Another great benefit of the integrated systems is that they are designed together with the vehicle and give possibilities to enhance protection of the child without adding possibly clumsy add-on parts to the child restraint system. The Volvo rear seat with the 2-stage integrated booster with seatbelt performance (as well as Inflatable Curtain coverage) adapted to the child is a good example of this.

For total child safety it is important to encourage more integrated systems and to facilitate good and simple booster cushions to attract the older age group of recommended usage and thus increase the overall booster usage rate.

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