## Lives Saved by Child Restraints from 1982 through 1987

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## Summary

Estimates derived from the Fatal Accident Reporting System (FARS) indicate that restraints are very effective in preventing infant (under one year old) and toddler (one through four years old) fatalities. It is estimated that fatality reductions from restraint use between 1982 and 1987 were:

69 percent for infants in child safety seats,
47 percent for toddlers in child safety seats, and
36 percent for toddlers in adult belts.

Because many restraints are incorrectly or incompletely used (as reported from detailed observation surveys), potential effectiveness is probably higher than the estimates provided here.

As child restraint use has increased, the annual number of lives saved has also increased. Based on the methods described here, child safety seats and adult belts used by infant and toddler passenger vehicle occupants saved an estimated:

75 lives in 1982,
105 lives in 1983,
126 lives in 1984,
153 lives in 1985,
166 lives in 1986, and
213 lives in 1987.
Child restraints could save many more lives, but use is still low in serious accidents. Observations taken at shopping centers in nineteen cities indicate that about 80 percent of young children (under five years old) who visited these centers in 1987 were in child safety seats. In contrast, only 24 percent of young children who survived a fatal accident were in child safety seats. Observations taken by individual states produce results that vary widely between these two extremes. Despite the effectiveness of child restraints and the widespread use of safety seats in some areas, children in serious crashes are usually umprotected.

If all young children used child restraints, more lives could be saved. With 100 percent use, child seats (with the mix of correct and incorrect use during 1982 through 1987) could have saved an estimated:

369 lives in 1982,
380 lives in 1983,
355 lives in 1984,
378 lives in 1985,
405 lives in 1986, and
462 lives in 1987.
If child seats are to achieve anything like this potential, they must become more available to children involved in serious crashes.

The remainder of this report describes the data and methods on which these conclusions are based.


#### Abstract

Data Between 1982 and 1987 there were 7,060 vehicles reported to FARS that met the following three criteria. First, they were passenger cars built after front seat lap and shoulder belts were required (model years 1974 and later). Second, they had a driver for whom restraint use was reported. And third, they had a young child passenger (under five years old) for whom restraint use and type (adult belts or child safety seat) was reported. The definitions used to select and classify these cases are described in Appendix Table A.


## Method

This paper uses the matched-pairs technique described in detail by leonard Evans (for example, in "Driver Fatalities versus Car Mass Using a New Exposure Approach," Accident Analysis and Prevention, Volume 16, Number 1, 1984) and used by him in a variety of studies of fatal accidents. This technique has been used in previous agency analyses of child restraints ("Restraint Use and Fatality Risk for Infants and Toddlers," Susan Partyka, 1984; "An Evaluation of Child Passenger Safety: The Effectiveness and Benefits of Safety Seats," Charles Kahane, 1986).

The idea is to compute fatality odds from FARS data and treat them as if they were fatality rates. For example, there were 4,239 vehicles in which neither the driver nor the child passenger was restrained. In these vehicles, there were 1,341 driver fatalities and 1,290 child passenger fatalities, as shown in Table 1. The ratio of child to driver fatalities was:

$$
1,290 / 1,341=0.962 .
$$

There were also 910 vehicles in which the driver was unrestrained, but the child passenger was in a child safety seat. There were 324 driver fatalities and 156 child passenger fatalities in these vehicles. The ratio of child to driver fatalities was:

$$
156 / 324=0.481
$$

If these fatality odds are interpreted as fatality rates, they can be used to estimate the effectiveness of child safety seats in vehicles with an unrestrained driver. Children in safety seats were:

$$
(0.962-0.481) / 0.962=50 \text { percent }
$$

less likely to be killed than were the unrestrained children in these fatal accidents. This result is shown in Table 2.

These estimates were made for each combination of driver and child restraint use, separately for front and rear seats, and separately for infants (those under one year old) and toddlers (those one through four years old). They are interpreted here as estimates of the effectiveness of child safety seats and adult belts in saving the lives of young children.

The method depends on three assumptions. First, that restraint use was correctly reported for fatalities and survivors of fatal accidents. Second, that unknown restraint use data were missing at random. And third, that the exposure of young children to potentially-fatal crashes was adequately represented by the number of fatalities among drivers of young children.

The data were also used to estimate the incremental benefits of rear (as opposed to front) seating for young children. For example, in vehicles with both the driver and child restrained, the fatality odds were:
$716 / 603=1.187$ for children in the front seat and
$466 / 590=0.790$ for children in the rear seat.

If these fatality odds are treated like fatality rates, the safety benefit of placing a young child in the rear seat can be estimated. Children in the rear seat were:

$$
(1.187-0.790) / 1.187=33 \text { percent }
$$

less likely to be killed than were children in the front seat. This result is shown in Table 3.

The combinations of driver restraint use, child restraint use, and child seating position produced multiple estimates of the effectiveness of adult belts and child safety seats in preventing fatalities among children and multiple estimates of the benefits of placing a child in the safer rear seat. In some cases there was good agreement among the estimates, but in others there was remarkable scatter.

Average effectiveness estimates were computed by weighting individual effectiveness estimates by a measure intended to reflect the relative reliability of the individual estimates. The reliability of the estimates usually was limited most by the small number of restrained children. So this measure (the number of vehicles with both a driver fatality and a restrained child passenger, used to calculate each individual estimate) was used to produce the weighted average estimate.

For example, child safety seat effectiveness in the front seats of passenger cars was estimated twice: once for vehicles with unrestrained drivers, and again for vehicles with restrained drivers. This produced estimates that child safety seats were 58 percent and 34 percent effective, respectively, in preventing fatality. The first estimate was based on data that included 114 vehicles with both a child in a child safety seat and an unrestrained driver fatality. The second estimate was based on data that included 35 vehicles with both a child in a child safety seat and a restrained driver fatality. The average of these estimates was computed as:
$\frac{(58 \text { percent * } 114 \text { vehicles })+(34 \text { percent * } 35 \text { vehicles })}{(114 \text { vehicles }+35 \text { vehicles) }}=52$ percent.
Using a different weighting factor (or using straight averaging) would produce different results from the ones reported here. The estimates of the benefits of rear (as opposed to front) seating are most sensitive to the selection of the weighting factor because the effectiveness estimates produced for various categories of driver and child restraint status varied so widely.

## Restraint Effectiveness

Table 1 shows the available data for children under five years old - all seating positions, those known to have been in the front seat, and those known to have been in a rear seat. The seating position of some young children was not known. These children are included in the summary across all seats, but not in either of the two known seat areas.

The fatality odds shown in Table 1 were used to compare the fatality experiences of unrestrained children to the experiences of children using child safety seats and adult seat belts. Young children in safety seats were 54 percent less likely to be killed than were unrestrained children. This should not be interpreted as an estimate of child safety seat effectiveness because of confounding differences between unrestrained and restrained children. Children in rear seats and infants were more likely to be restrained than were children in front seats and toddlers. The biasing effects of these two differences can be removed statistically from the fatality data.

The first difference noted above is that unrestrained children more often rode in the front seat than in the rear seat, while children in safety seats more often rode in the safer rear seat. Because the rear seat is more protective, this difference produces a statistical bias in favor of child safety seats. To compensate for this difference, the data of Table 1 were used to produce separate estimates of fatality reductions for front seat and for rear seat occupants.

It is estimated from these data that child safety seats are 52 percent effective in preventing fatality in front seats and 47 percent effective in preventing fatality in rear seats (Table 2). The difference between these two estimates appears small enough to have resulted fram chance. The weighted average of these two estimates is 49 percent. This is the estimated effectiveness of child safety seats in preventing fatality, controlling for differences in seating position between unrestrained children and children in safety seats.

Similar calculations produce an estimate that adult belts are 44 percent effective in preventing fatality, after controlling for seating position differences between unrestrained and belted children.

The data in Table. 1 can also be used to compare the fatality odds of children in the front and rear seats, after controlling for driver and child restraint type. Table 3 shows that, on average, a young child was 26 percent less likely to be killed in a rear seat than in the front seat. However, there were large differences in the estimates produced by the various categories of driver and child restraint status. At this time, there appears to be no pattern in the variety of estimates. The variation may reflect reporting biases, the inherent variability of the data, or a physical process that is not yet understood.

Table 1: Fatalities of Drivers and their Young Child Passengers (Children Under Five Years Old, 1982-1987 Data)

| Child's position | Restraint Used by |  | Number of Deaths |  | Ratio of Fatalities |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Driver/ | Child |
|  | priver | Child |  |  | Driver | Child | Child | Driver |
| * All Seats | None | None | 1,341 | 1,290 | 1.040 | 0.962 |
|  | None | Adult belt | 84 | 42 | 2.000 | 0.500 |
|  | None | child seat | 324 | 156 | 2.077 | 0.481 |
|  | Belts | None | 60 | 120 | 0.500 | 2.000 |
|  | Belts | Adult belt | 87 | 88 | 0.989 | 1.011 |
|  | Belts | Child seat | 178 | 137 | 1.299 | 0.770 |
| Front | None | None | 603 | 716 | 0.842 | 1.187 |
|  | None | Adult belt | 28 | 14 | 2.000 | 0.500 |
|  | None | Child seat | 114 | 57 | 2.000 | 0.500 |
|  | Belts | None | 23 | 44 | 0.523 | 1.913 |
|  | Belts | Adult belt | 34 | 39 | 0.872 | 1.147 |
|  | Belts | Crild seat | 35 | 44 | 0.795 | 1.257 |
| Rear | None | None | 590 | 466 | 1.266 | 0.790 |
|  | None | Adult belt | 54 | 28 | 1.929 | 0.519 |
|  | None | Child seat | 197 | 99 | 1.990 | 0.503 |
|  | Belts | None | 34 | 63 | 0.540 | 1.853 |
|  | Belts | Adult belt | 49 | 46 | 1.065 | 0.939 |
|  | Belts | Child seat | 135 | 92 | 1.467 | 0.681 |

* Children with unknown seat position included in "All Seats."

Table 2: Estimated Percentage Benefits of Restraint Use by Young Children

| Child Restrained by | Control Used | No Seat Position Benefit in: |  |  | Average Benefit |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Control | Front | Rear |  |
| Adult seat belt | Unrestrained driver | 48 | 58 | 34 | 42 |
|  | Restrained driver | 49 | 40 | 49 | 46 |
|  | Average | 49 | 48 | 41 | 44 |
| Child safety seat | Unrestrained driver | 50 | 58 | 36 | 44 |
|  | Restrained driver | 62 | 34 | 63 | 57 |
|  | Average | 54 | 52 | 47 | 49 |

Table 3: Estimated Percentage Benefits of Rear Seating for Young Children within Categories of Driver and Child Restraint Use

|  | Restraint Use of Driver Control |  |  |
| :---: | :---: | :---: | :---: |
| Child Restrained by | Unrestrained | Restrained | Average |
| None | 33 | 3 | 32 |
| Adult seat belt | -4 | 18 | 7 |
| Child safety seat | -1 | 46 | 16 |
| Average | 25 | 31 | 26 |

The second difference between unrestrained and restrained children noted previously is that infants were more frequently restrained (especially in a child safety seat) than were toddlers. Because infants are more vulnerable to injury than are older children, this difference produces a statistical bias against child safety seats. To compensate for this difference, the data of Table 1 for all young children were separately tabulared for infants (Table 4) and toddlers (Table 7). The data from these two tables were used to produce separate estimates of fatality reductions for infants and toddlers, for front and for rear seat occupants.

The separate calculations performed are summarized for infants (those under one year old) in Tables 4 through 6 and for toddlers (those one through four years old) in Tables 7 through 9. The data for adult-belted infants are inadequate for meaningful estimates. The estimated fatality reductions from restraint use (controlling for differences in seat positions of unrestrained and restrained children) are:

69 percent for infants in child safety seats, 47 percent for toddlers in child safety seats, and 36 percent for toddlers in adult belts.

In each case, accounting for differences in seating positions of unrestrained versus restrained children produces estimated fatality benefits that are between three and five percentage points lower than the estimates produced without adjusting for this difference.

The estimated average benefit of sitting in a rear seat was 29 percent for infants and 19 percent for toddlers. For infants, the estimated benefits were higher for cases with a restrained driver but did not seem to depend on the restraint status of the child. The estimates derived for toddlers varied widely, depending on the restraint status of the driver and of the toddler. The reasons for these differences are not currently understood.

Table 4: Fatalities of Drivers and their Infant Passengers (Children Under One Year Old, 1982-1987 Data)

| Child's position | Restraint Used by |  | Number of Deaths |  | Ratio of Fatalities |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Driver/ | Child |
|  | Driver | Child |  |  | Driver | Child | Child | Driver |
| * All Seats | None | None | 196 | 332 | 0.590 | 1.694 |
|  | None | Adult belt | 3 | 2 | 1.500 | 0.667 |
|  | None | Child seat | 99 | 58 | 1.707 | 0.586 |
|  | Belts | None | 3 | 26 | 0.115 | 8.667 |
|  | Belts | Adult belt | 5 | 7 | 0.714 | 1.400 |
|  | Belts | Crild seat | 42 | 44 | 0.955 | 1.048 |
| Front | None | None | 122 | 237 | 0.515 | 1.943 |
|  | None | Adult belt | 3 | 1 | 3.000 | 0.333 |
|  | None | child seat | 38 | 28 | 1.357 | 0.737 |
|  | Belts | None | 1 | 11 | 0.091 | 11.000 |
|  | Belts | Adult belt | 4 | 5 | 0.800 | 1.250 |
|  | Belts | Child seat | 9 | 14 | 0.643 | 1.556 |
| Rear | None | None | 53 | 76 | 0.697 | 1.434 |
|  | None | Adult belt | 0 | 1 | 0.000 | - |
|  | None | Child seat | 57 | 30 | 1.900 | 0.526 |
|  | Belts | None | 2 | 11 | 0.182 | 5.500 |
|  | Belts | Adult belt | 0 | 1 | 0.000 | - |
|  | Belts | Child seat | 32 | 30 | 1.067 | 0.938 |

* Children with unknown seat position included in "All Seats."

Table 5: Estimated Percentage Benefits of Restraint Use by Infants

|  |  | No Seat <br> Cosition |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Child Restrained by |  |  | Benefit in: | Average |
| :---: |

Table 6: Estimated Percentage Benefits of Rear Seating for Infants with Categories of Driver and Child Restraint Use

| Child Restrained by | Restraint Use of Driver Control |  |  |
| :---: | :---: | :---: | :---: |
|  | Unrestrained | Restrained | Average |
| None | 26 | 50 | 27 |
| Child safety seat | $\underline{29}$ | 40 | 32 |
| Average | 27 | 40 | 29 |

Table 7: Fatalities of Drivers and their Toddler Passengers
(Children one through Four Years Old, 1982-1987 Data)

| Chiia's position | Restraint Used by |  | Number of Deaths |  | Ratio of Fatalities |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Driver/ | Child |
|  | Driver | child |  |  | Driver | Child | Child | Driver |
| * All Seats | None | None | 1,145 | 958 | 1.195 | 0.837 |
|  | None | Adult belt | 81 | 40 | 2.025 | 0.494 |
|  | None | Child seat | 225 | 98 | 2.296 | 0.436 |
|  | Belts | None | 57 | 94 | 0.606 | 1.649 |
|  | Belts | Adult belt | 82 | 81 | 1.012 | 0.988 |
|  | Belts | Child seat | 136 | 93 | 1.462 | 0.684 |
| Front | None | None | 481 | 479 | 1.004 | 0.996 |
|  | None | Adult belt | 25 | 13 | 1.923 | 0.520 |
|  | None | Child seat | 76 | 29 | 2.621 | 0.382 |
|  | Belts | None | 22 | 33 | 0.667 | 1.500 |
|  | Belts | Adult belt | 30 | 34 | 0.882 | 1.133 |
|  | Belts | Crild seat | 26 | 30 | 0.867 | 1.154 |
| Rear | None | None | 537 | 390 | 1.377 | 0.726 |
|  | None | Adult belt | 54 | 27 | 2.000 | 0.500 |
|  | None | Child seat | 140 | 69 | 2.029 | 0.493 |
|  | Belts | None | 32 | 52 | 0.615 | 1.625 |
|  | Belts | Adult belt | 49 | 45 | 1.089 | 0.918 |
|  | Belts | Child seat | 103 | 62 | 1.661 | 0.602 |

* Children with unknown seat position included in "All Seats."

Table 8: Estimated Percentage Benefits of Restraint Use by Toddlers

| Child Restrained by | Control Used | No Seat Position Benefit in: |  |  | Average Benefit |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | control | Front | Rear |  |
| Adult seat belt | Unrestrained driver | 41 | 48 | 31 | 36 |
|  | Restrained driver | 40 | $\underline{24}$ | 43 | 36 |
|  | Average | 41 | 35 | 37 | 36 |
| Child safety seat | Unrestrained driver | 48 | 62 | 32 | 43 |
|  | Restrained driver | 59 | $\underline{23}$ | 63 | 55 |
|  | Average | 52 | 52 | 45 | 47 |

Table 9: Estimated Percentage Benefits of Rear Seating for Toddlers within Categories of Driver and Child Restraint Use

| Child Restrained by | Restraint Use of Driver Control |  |  |
| :---: | :---: | :---: | :---: |
|  | Unrestrained | Restrained | Average |
| None | 27 | -8 | 25 |
| Adult seat belt | 4 | 19 | 11 |
| Child safety seat | -29 | 48 | 0 |
| Average | 17 | 28 | 19 |

## Lives Saved by Restraints

Appendix Table B shows counts of young childrem killed as occupants of passenger vehicles (cars, pickups, vans, and multipurpose vehicles) by accident year, age, and reported restraint use. For each row of this table, the unknown data were prorated among the known data in two steps. First, fatalities with unknown restraint use were prorated between fatalities in child seats and adult seat belts. And second, fatalities for whom it was not known whether or not they were restrained were prorated across the resulting estimates of fatalities in child seats and in adult belts and fatalities reported as unrestrained. The results are shown in Appendix Table C.

The estimates of Appendix Table C were collapsed to produce estimates of restraint use by fatally-injured infants and toddlers, shown in table 10. It is estimated that in 1982 there were 48 young children killed in a child safety seat ( 7.8 percent of young children killed in passenger vehicles that year). In 1987, there were an estimated 135 young children killed in a safety seat ( 20.6 percent of young child occupants killed that year).

Table 10: Estimated Type of Restraint Used by Fatalities Categorized into Infants and Toddlers

|  |  | Estimated Fatality Counts |  |  |  | Estimated Percent Use |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | None | Child | Adult |  | Child | Adult | Total |
| $\frac{\text { Year }}{1982}$ | Age | Used | Seat | Belt | Total | Seat | Belt | Use |
|  | 0 | 145 | 19 | 0 | 164 | 11.6 | 0.0 | 11.6 |
|  | 1-4 | 407 | $\underline{29}$ | 13 | 449 | 6.5 | 2.9 | 9.4 |
|  | 0-4 | 552 | 48 | 13 | 613 | 7.8 | 2.1 | 10.0 |
| 1983 | 0 | 130 | 26 | 1 | 157 | 16.6 | 0.6 | 17.2 |
|  | 1-4 | 387 | 42 | 16 | 445 | 9.4 | 3.6 | 13.0 |
|  | 0-4 | 517 | 68 | 17 | 602 | 11.3 | 2.8 | 14.1 |
| 1984 | 0 | 103 | 28 | 1 | 132 | 21.2 | 0.8 | 22.0 |
|  | 1-4 | 325 | 55 | 25 | 405 | 13.6 | 6.2 | 19.8 |
|  | 0-4 | 428 | 83 | 26 | 537 | 15.5 | 4.8 | 20.3 |
| 1985 | 0 | 94 | 34 | 2 | 130 | 26.2 | 1.5 | 27.7 |
|  | 1-4 | 327 | 67 | 30 | 424 | 15.8 | 7.1 | $\underline{22.9}$ |
|  | 0-4 | 421 | 101 | 32 | 554 | 18.2 | 5.8 | 24.0 |
| 1986 | 0 | 91 | 33 | 6 | 130 | 25.4 | 4.6 | 30.0 |
|  | 1-4 | 347 | 67 | 55 | 469 | 14.3 | 11.7 | $\underline{26.0}$ |
|  | 0-4 | 438 | 100 | 61 | 599 | 16.7 | 10.2 | 26.9 |
| 1987 | 0 | 113 | 39 | 6 | 158 | 24.7 | 3.8 | 28.5 |
|  | 1-4 | 333 | 96 | 67 | 496 | 19.4 | 13.5 | 32.9 |
|  | 0-4 | 446 | 135 | 73 | 654 | 20.6 | 11.2 | 31.8 |
| $\begin{array}{r} 1982 \\ -87 \end{array}$ | 0 | 676 | 179 | 16 | 871 | 20.6 | 1.8 | 22.4 |
|  | 1-4 | 2,126 | 356 | 206 | 2. 688 | 13.2 | 7.7 | $\underline{20.9}$ |
|  | 0-4 | 2,802 | 535 | 222 | 3,559 | 15.0 | 6.2 | 21.3 |

These estimates of young restrained children killed in passenger vehicles were combined with the restraint effectiveness estimates produced in the previous section, to form estimates of lives saved by restraints. The estimated effectiveness of adult belts in preventing toddler fatality was used as the estimate for infants; a separate infant estimate could not be derived from the few available cases of adult-belted infants.

Child restraint benefits were calculated as:

$$
\text { Lives Saved }=\text { Fatalities } * \frac{\text { Restraint Effectiveness }}{1-\text { Restraint Effectiveness }} .
$$

The results are shown in Table 11.

Table 11: Estimated Young Children Saved by Restraints

|  | Infants |  |  | Toddlers |  |  | Infants + Toddlers |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Adult Child Total Belt Seat Use |  |  | Adult Child Total Belt Seat Use |  |  | Adult Child Total Belt Seat Use |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Estimated Restrained Fatalities |  |  |  |  |  |  |  |  |  |
| 1982 | 0 | 19 | 19 | 13 | 29 | 42 | 13 | 48 | 61 |
| 1983 | 1 | 26 | 27 | 16 | 42 | 58 | 17 | 68 | 85 |
| 1984 | 1 | 28 | 29 | 25 | 55 | 80 | 26 | 83 | 109 |
| 1985 | 2 | 34 | 36 | 30 | 67 | 97 | 32 | 101 | 133 |
| 1986 | 6 | 33 | 39 | 55 | 67 | 122 | 61 | 100 | 161 |
| 1987 | 6 | 39 | 45 | 67 | 96 | 163 | 73 | 135 | 208 |
| 1982-1987 | 16 | 179 | 195 | 206 | 356 | 562 | 222 | 535 | 757 |
| Estimated |  |  |  |  |  |  |  |  |  |
| Percent |  |  |  |  |  |  |  |  |  |
| Fatality |  |  |  |  |  |  |  |  |  |
| Reduction | 0.36 | 0.69 | - | 0.36 | 0.47 | - | - | - | - |
| Estimated <br> Lives Saved |  |  |  |  |  |  |  |  |  |
| 1982 | 0 | 42 | 42 | 7 | 26 | 33 | 7 | 68 | 75 |
| 1983 | 1 | 58 | 59 | 9 | 37 | 46 | 10 | 95 | 105 |
| 1984 | 1 | 62 | 63 | 14 | 49 | 63 | 15 | 111 | 126 |
| 1985 | 1 | 76 | 77 | 17 | 59 | 76 | 18 | 135 | 153 |
| 1986 | 3 | 73 | 76 | 31 | 59 | 90 | 34 | 132 | 166 |
| 1987 | 3 | 87 | 90 | 38 | 85 | 123 | 41 | 172 | $\underline{213}$ |
| 1982-1987 | 9 | 398 | 407 | 116 | 315 | 431 | 125 | 713 | 838 |

This procedure produces an estimate that 213 young child occupants of passenger vehicles were saved by restraint use in 1987 - 172 in child safety seats and 41 in adult belts. Between 1982 and 1987, child safety seats saved an estimated 713 lives. Adult belts saved an additional 125 lives, for a total of 838 young children saved by restraints in these six years.

Potential Lives Saved by Restraints
If all young children had been using a child safety seat, more lives could have been saved. Estimates of the number savable each year were calculated from total fatalities (Table 10), lives saved by restraints (Table 11), and effectiveness of restraints as used during these six years, as follows:

```
Infant Lives That Could Be Saved
    = (Total Fatalities + Lives Saved) * 0.69, and
Toddler Lives That Could Be Saved
    = (Total Fatalities + Lives Saved) * 0.47.
```

At these effectiveness levels, safety seats could have saved an average of 400 lives a year. The potential benefits depend on the number of children involved in accidents each year and the mix of infants (for whom child safety seats are very effective) and toddlers (for whom effectiveness has been lower, perhaps because of more frequent incorrect use). The estimates are shown in Table 12.

More young children are being saved each year because of increased child seat use in serious crashes. In 1982, about one-fifth of the lives that could be saved with 100 percent use of child restraints were saved. By 1987, close to one-half of the potential lives saved (given the actual mix of correct and incorrect use modes) were actually saved. The data are shown in Table 13.

Table 12: Estimates of Lives Savable by Child Seats as Used during 1982 through 1987

| Year | Infants | Toddlers | Total |
| :---: | :---: | :---: | :---: |
| 1982 | 142 | 227 | 369 |
| 1983 | 149 | 231 | 380 |
| 1984 | 135 | 220 | 355 |
| 1985 | 143 | 235 | 378 |
| 1986 | 142 | 263 | 405 |
| 1987 | 171 | 291 | 462 |
| Total | 882 | 1,466 | 2,348 |


| Year | Infants | Toddlers | Total |
| :---: | :---: | :---: | :---: |
| 1982 | $30 \%$ | 15 \% | $20 \%$ |
| 1983 | $40 \%$ | 20 \% | 28 \% |
| 1984 | 47 \% | 29 \% | 35 \% |
| 1985 | 54 \% | 32 \% | $40 \%$ |
| 1986 | 54 \% | 34 \% | 41 \% |
| 1987 | 53 \% | 42\% | $46 \%$ |
| Total | 46 \% | 29 \% | $36 \%$ |

## Discussion

These estimates of restraint effectiveness for young children depend on three assumptions. First, that restraint use was correctly reported for young children and their drivers in fatal aocidents. Second, that the unknown data on restraint use and type were missing at randam. And third, that driver fatalities in passenger vehicles with young child occupants were an adequate exposure measure for the risks of death to young children.

It is not possible to test these assumptions directly. However, it seems that unrestrained people reported as restrained (the issue of the first assumption) would be more common for adult belts (whether used by drivers or by children) than for child seats. The presence of a child seat, if not the child in the seat and the correctness of its use, is obvious. The device has been bought specially, presumably because the child's parent believes in either its value or its legal necessity. In contrast, adult belts are standard in all passenger vehicles. Their presence in the vehicle does not indicate a cormittment to their use.

Unknown restraint use data (the issue of the second assumption) frequently reflects the police accident report form used in a particular state. Some states do not routinely report restraint use (there is no restraint use data element on the police report) or do not routinely report restraint type used (the restraint use data element includes only codes for yes and no). In these states, restraint use or restraint type is reported to FARS only if the police officer described it in the narrative portion of the police report. These unknown data resemble the known data on the FARS file to the extent that restraint use in these states resembles restraint use in states with more, or more-detailed, restraint use coding.

The adequacy of driver fatalities as a measure of child fatality risk (the issue of the third assumption) is unclear. It is possible that child restraints prevent fatalities in crashes that pose little risk to the driver. If child restraints are most effective in low-severity crashes (for example, by preventing ejections of small people through open windows), then this estimation method underestimates the value of child restraints. Lives saved by child seats will not be reported to FARS unless sameone else in the accident dies. If this is the case, the estimates provided here may be better described as the effectiveness of child restraints in high-severity accidents.

As a check of the process as a whole, the data of Table 1 were used to calculate car driver seat belt effectiveness (with child fatalities as the standardizing factor). The results are shown in Table 14.

Table 14: Effectiveness of Seat Belts for Car Drivers (Percentage Fatality Reduction)
Control Used
Unrestrained child
Adult belted child
Child seated child
Average

| Child's | Seat Position in car |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Overall | Front | Rear | Average |
|  | $\frac{52}{38}$ | $\frac{57}{48}$ | 48 |
| 51 | 56 | 45 | 51 |
| $\frac{37}{47}$ | $\frac{60}{51}$ | $\frac{26}{43}$ | $\frac{43}{47}$ |

This method produced an estimate that driver seat belts were 47 percent effective in preventing driver fatality (on average, across the three categories of child restraint status). Individual estimates varied from 43 percent (for drivers with children in safety seats) to 48 percent (for drivers of unrestrained children) to 51 percent (for drivers with children in adult belts). These are within the agency's estimated range ( 40 to 50 percent) of lap and shoulder belt effectiveness.

There is a problem in reconciling the child restraint benefits (realized and potential) estimated here with the prevalent child safety seat use reported in some observation surveys. It is estimated that 213 children were saved by restraints in 1987, but that 462 could have been saved if all young children had used child safety seats. This implies that many children were unrestrained in accidents. Table 15 shows (based on the detailed data in Appendix Tables D and E) that it is estimated that only a half of all young children who survived a fatal traffic accident were using any kind of restraint in 1987.

Table 15: Estimated Type of Restraint Used by Survivors of Fatal Aocidents Categorized into Infants and Toddlers


In contrast, observations taken by the agency's 19-Cities Survey (managed by the Office of Driver and Pedestrian Research) indicate that restraint use near the shorming centers included in the survey was much higher. By 1987, the survey was reporting that four-fifths of young children (both infants and toddlers) were restrained.

Differences between infants and toddlers have disappeared in the survey data. In 1981, twice as many infants as toddlers were using child restraints: 40.4 percent of those under one year old, campared to only 19.4 percent of those aged one through four years old. By 1987, approximately four-fifths of each age group were abserved using child restraints: 77.5 percent of those under one year old and 80.1 percent of those aged one through four years. The uniformly high child restraint use rates reported from observation surveys appear to conflict with the lower use rates reported for children (especially toddlers) in fatal accidents. The data for infants and for toddlers are shown in Tables 16 and 17, respectively.

Table 16: Changes in Infant Use of Child Restraints

| Year | 19-Cities | Survivors | Fatalities |
| :---: | :---: | :---: | :---: |
| 1982 | n/a | 23.6 | 11.6 |
| 1983 | 60.4 | 35.2 | 16.6 |
| 1984 | 66.4 | 47.6 | 21.2 |
| 1985 | 66.4 | 56.3 | 26.2 |
| 1986 | 70.0 | 49.6 | 25.4 |
| 1987 | 77.5 | 54.4 | 24.7 |

Table 17: Changes in Toddler Use of Child Restraints

|  |  | FARS Fatal Accidents |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Year |  | 19-Cities |  | Survivors | Fatalities

Table 18: Changes in Toddler Use of Adult Restraints

|  |  | FARS Fatal Accidents |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Year. | 19-Cities |  | Survivors |  |
| 1982 | natalities |  | Fata | 4.6 |
| 1983 | 5.3 | 5.6 | 3.9 |  |
| 1984 | 7.4 | 9.3 | 6.6 |  |
| 1985 | 9.3 | 12.1 | 7.1 |  |
| 1986 | 5.9 | 18.9 | 11.7 |  |
| 1987 | 4.7 | 22.2 | 13.5 |  |

Large (and increasing) numbers of young children in fatal accidents were reported to have been using an adult belt (Table 18). By 1987, 22.2 percent of toddlers who survived a fatal accident were reported to have been using an adult belt. The accuracy of these data is not known. But even among toddler fatalities (whose restraint reporting is believed to be more accurate), adult belt use was reported as 13.5 percent in 1987. In contrast, even in recent years few toddlers ( 4.7 percent in 1987) were observed in adult belts in traffic near shopping centers.

Reported child restraint use in fatal accidents declined rapidly with the age of the child. While high levels of restraint use were reported for those under two years old, older children were less frequently reported to have been restrained in the accident. Fewer than 10 percent of four year olds were reported to have been using a child restraint in a fatal accident (whether the child survived or was killed). The 1987 data are shown in Table 19. The observation survey does not report the individual age of a toddler.

Table 19: Child Restraint Use in 1987, by Child Age

|  |  | FARS Fatal Aocidents |  |
| :---: | :---: | :---: | :---: |
| Age | 19-Cities | Survivors | Fatalities |
| 0 | 77.5 | 54.4 | 24.7 |
| $1-4$ | 80.1 | 26.8 | 19.4 |
|  |  |  |  |
| 0 | 77.5 | 54.4 | 24.7 |
| 1 | n/a | 50.1 | 32.6 |
| 2 | n/a | 30.8 | 24.2 |
| 3 | n/a | 21.7 | 13.5 |
| 4 | n/a | 6.9 | 5.3 |

The low child restraint use reported for three and four year olds in fatal accidents (compared to the high use reported for younger children) suggests a possible reporting problem. It may be difficult to estimate the age of older toddlers under the observation conditions. A child in a child restraint may more obviously be a toddler than the same child riding unrestrained or in an adult belt. A particular child may look four years old when seated in a child restraint, but look five years old when using an adult belt. However, traffic observers used the same protocol in 1987 as in 1981, and many observers who collected the earlier data also collected the more recent data.

Another possibility is that the children observed by the 19-Cities Survey are not completely representative of children involved in serious accidents. This may be for either of at least two reasons. First, children in the areas surveyed may not adequately represent young children in traffic in all areas of the country. And second, young children in traffic may not adequately represent young children who became involved in serious accidents. These two possibilities are discussed further below.

First, the 19-Cities Survey of young children is based near shopping centers to increase the numbers observed. The survey may tend to include people who can afford to buy child restraints and to exclude people who feel they can only afford to put their children in the available adult seat belts. Heople for whom child restraints are very expensive may tend to shop elsewhere. The result would be an overestimate of child restraint use in traffic. The cost of the child restraint may be a particular problem for toddlers because they are less accessible to maternity-based information and loaner programs than they were as newborns.

This possibility is partially supported by child restraint use reported by individual states. Some states (such as California and North Carolina) report high rates of child restraint use, comparable to the rates observed by the 19-Cities Survey. However, many other states report child restraint use rates of less than 40 percent.

Second, it has been observed that adult restraint use in accidents is lower than restraint use observed in traffic. It is likely that child restraint use is also lower in serious accidents than it is in general traffic. People who put young children in child restraints may tend to get into fewer and less-serious accidents than people who drive with unrestrained children. The result would be optimistic estimates of child restraint use in accidents from the observation data. The unrestrained children in the observation surveys may be at greater risk of becoming involved in a serious accident than are the restrained children.

This possibility is partially supported by accident data. Restraint use by children who survived a fatal accident in 1987 was slightly higher in urban areas and during the day than in rural areas and at night. These conditions of higher child restraint use correspond to 19-Cities Survey observation conditions.

In summary, it appears clear than restraint use in accidents is much lower than reported in observation surveys, particularly in the agency's 19-Cities Survey. While child restraint use has increased over the last five years, children in serious accidents are still all too often unprotected. This situation is similar to that of the high risk adult population, who are less likely to use safety belts than is the general population. Further fatality reductions will require greater use of child safety seats where they are most needed -- in serious crashes.

## Appendix of Detailed Tables

Appendix Table A: Definitions

| Category | FARS Data Element Coding |
| :---: | :---: |
| Vehicle Type: |  |
| passenger Vehicle | $\begin{aligned} & \text { Body Types 1-12, 40-41, 48-51, } \\ & 53-56,58-58,67-69 \end{aligned}$ |
| Passenger Car | Body Types 1-11, 67 |
| Lap and Shoulder Belt Equipped | Model Years 74-88 |
| Driver | Seat Position 11 and Age 5-99 |
| Driver Restraint Use: |  |
| Unrestrained | Manual Restraint 0 and Autamatic Restraint not 1 and Autamatic Restraint not 3 |
| Restrained | Manual Restraint 1-8 or Automatic Restraint 1 or Autamatic Restraint 3 |
| Child Age: |  |
| Young Child | Age 0-4 |
| Infant. | Age 0 |
| Toddler | Age 1-4 |
| Child Restraint Use: |  |
| Unrestrained | Manual Restraint 0 and Autonatic Restraint not 1 and Automatic Restraint not 3 |
| Adult Belted | (Manual Restraint 1-7 or Automatic Restraint 1 or Automatic Restraint 3) and Manual Restraint not 4 |
| Child Safety Seated | Manual Restraint 4 |
| Child Seat Position: |  |
| Front Seat | Seat Positions 12-19 |
| Rear Seat | Seat Positions 21-49 |
| Occupant Outcame: |  |
| Killed | Injury Severity 4 |
| Survived | Injury Severity not 4 |

Appendix Table B:
Fatalities by Police-Reported Restraint Use

| Year | Age | None Used | Type Restraint Used |  |  |  | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | child | Adult Belt | Unknown Type | Unknown if Used |  |
| 1982 | $\frac{\text { Age }}{0}$ | $\frac{124}{}$ | 15 | 0 | 1 | 24 | 164 |
|  | 1 | 80 | 13 | 2 | 2 | 13 | 110 |
|  | 2 | 104 | 6 | 5 | 1 | 14 | 130 |
|  | 3 | 92 | 4 | 1 | 1 | 13 | 111 |
|  | 4 | 82 | 0 | 3 | 0 | 13 | 98 |
| 1983 | 0 | 117 | 23 | 1 | 0 | 16 | 157 |
|  | 1 | 95 | 17 | 3 | 3 | 4 | 122 |
|  | 2 | 98 | 10 | 2 | 1 | 8 | 119 |
|  | 3 | 87 | 6 | 7 | 2 | 12 | 114 |
|  | 4 | 77 | 2 | 1 | 0 | 10 | 90 |
| 1984 | 0 | 96 | 25 | 1 | 1 | 9 | 132 |
|  | 1 | 48 | 22 | 1 | 1 | 8 | 80 |
|  | 2 | 75 | 11 | 10 | 2 | 13 | 111 |
|  | 3 | 84 | 5 | 3 | 1 | 15 | 108 |
|  | 4 | 79 | 6 | 6 | 2 | 12 | 105 |
| 1985 | 0 | 85 | 29 | 2 | 2 | 12 | 130 |
|  | 1 | 63 | 23 | 4 | 0 | 3 | 93 |
|  | 2 | 83 | 23 | 13 | 2 | 7 | 128 |
|  | 3 | 84 | 8 | 1 | 2 | 9 | 104 |
|  | 4 | 71 | 5 | 8 | 1 | 13 | 98 |
| 1986 | 0 | 83 | 30 | 5 | 0 | 12 | 130 |
|  | 1 | 84 | 25 | 3 | 2 | 9 | 123 |
|  | 2 | 81 | 18 | 14 | 1 | 10 | 124 |
|  | 3 | 81 | 8 | 10 | 3 | 9 | 111 |
|  | 4 | 72 | 5 | 14 | 9 | 11 | 111 |
| 1987 | 0 | 109 | 35 | 5 | 3 | 6 | 158 |
|  | 1 | 75 | 36 | 7 | 5 | 10 | 133 |
|  | 2 | 69 | 25 | 17 | 4 | 9 | 124 |
|  | 3 | 89 | 15 | 12 | 1 | 9 | 126 |
|  | 4 | 75 | 5 | 22 | 2 | 10 | 114 |
| 1982 | 0 | 614 | 157 | 14 | 7 | 79 | 871 |
| -87 | 1 | 445 | 136 | 20 | 13 | 47 | 661 |
|  | 2 | 510 | 93 | 61 | 11 | 61 | 736 |
|  | 3 | 517 | 46 | 34 | 10 | 67 | 674 |
|  | 4 | 456 | 23 | 54 | 14 | 69 | 616 |

All data as reported on FARS

Appendix Table C:
Fatalities by Estimated Restraint Use

| Year | Age | Estimated Use |  |  |  | Estimated Percent Use |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | None | Child | Adult |  | Child | Adult | Total |
|  |  | Used | Seat | Belt | Total | Seat | Belt | Use |
| 1982 | 0 | 145 | 19 | 0 | 164 | 11.6 | 0.0 | 11.6 |
|  | 1 | 91 | 17 | 3 | 111 | 15.3 | 2.7 | 18.0 |
|  | 2 | 117 | 7 | 6 | 130 | 5.4 | 4.6 | 10.0 |
|  | 3 | 104 | 5 | 1 | 110 | 4.5 | 0.9 | 5.5 |
|  | 4 | 95 | 0 | 3 | 98 | 0.0 | 3.1 | 3.1 |
| 1983 | 0 | 130 | 26 | 1 | 157 | 16.6 | 0.6 | 17.2 |
|  | 1 | 98 | 20 | 4 | 122 | 16.4 | 3.3 | 19.7 |
|  | 2 | 105 | 12 | 2 | 119 | 10.1 | 1.7 | 11.8 |
|  | 3 | 97 | 8 | 9 | 114 | 7.0 | 7.9 | 14.9 |
|  | 4 | 87 | 2 | 1 | 90 | 2.2 | 1.1 | 3.3 |
| 2984 | 0 | 103 | 28 | 1 | 132 | 21.2 | 0.8 | 22.0 |
|  | 1 | 53 | 26 | 1 | 80 | 32.5 | 1.3 | 33.8 |
|  | 2 | 85 | 14 | 12 | 111 | 12.6 | 10.8 | 23.4 |
|  | 3 | 98 | 7 | 4 | 109 | 6.4 | 3.7 | 10.1 |
|  | 4 | 89 | 8 | 8 | 105 | 7.6 | 7.6 | 15.2 |
| 1985 | 0 | 94 | 34 | 2 | 130 | 26.2 | 1.5 | 27.7 |
|  | 1 | 65 | 24 | 4 | 93 | 25.8 | 4.3 | 30.1 |
|  | 2 | 88 | 26 | 15 | 129 | 20.2 | 11.6 | 31.8 |
|  | 3 | 92 | 11 | 1. | 104 | 10.6 | 1.0 | 11.5 |
|  | 4 | 82 | 6 | 10 | 98 | 6.1 | 10.2 | 16.3 |
| 1986 | 0 | 91 | 33 | 6 | 130 | 25.4 | 4.6 | 30.0 |
|  | 1 | 91 | 29 | 3 | 123 | 23.6 | 2.4 | 26.0 |
|  | 2 | 88 | 20 | 16 | 124 | 16.1 | 12.9 | 29.0 |
|  | 3 | 88 | 10 | 13 | 111 | 9.0 | 11.7 | 20.7 |
|  | 4 | 80 | 8 | 23 | 111 | 7.2 | 20.7 | 27.9 |
| 1987 | 0 | 113 | 39 | 6 | 158 | 24.7 | 3.8 | 28.5 |
|  | 1 | 81 | 43 | 8 | 132 | 32.6 | 6.1 | 38.6 |
|  | 2 | 74 | 30 | 20 | 124 | 24.2 | 16.1 | 40.3 |
|  | 3 | 96 | 17 | 13 | 126 | 13.5 | 10.3 | 23.8 |
|  | 4 | 82 | 6 | 26 | 114 | 5.3 | 22.8 | 28.1 |
| $\begin{array}{r} 1982 \\ -87 \end{array}$ | 0 | 676 | 179 | 16 | 871 | 20.6 | 1.8 | 22.4 |
|  | 1 | 479 | 159 | 23 | 661 | 24.1 | 3.5 | 27.5 |
|  | 2 | 557 | 109 | 71 | 737 | 14.8 | 9.6 | 24.4 |
|  | 3 | 575 | 58 | 41 | 674 | 8.6 | 6.1 | 14.7 |
|  | 4 | 515 | 30 | 71 | 616 | 4.9 | 11.5 | 16.4 |

Data estimated by prorating "unknown restraint type" across known types and "unknown whether or not restrained" across other restraint categories within accident year and individual year of occupant age

Appendix Table D:
Survivors of Fatal Aocidents, by Police-Reported Restraint Use


All data as reported on FARS

Appendix Table E:
Survivors of Fatal Accidents, by Estimated Restraint Use

|  |  | Estimated Use |  |  |  | Estimated Percent Use |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | None | Crild | Adult |  | Child | Adult | Total |
| $\frac{\text { Year }}{1982}$ | Age | Used | Seat | Belt | Total | Seat | Belt | Use |
|  | 0 | 173 | 55 | 5 | 233 | 23.6 | 2.1 | 25.8 |
|  | 1 | 268 | 47 | 21 | 336 | 14.0 | 6.3 | 20.2 |
|  | 2 | 353 | 32 | 11 | 396 | 8.1 | 2.8 | 10.9 |
|  | 3 | 341 | 7 | 14 | 362 | 1.9 | 3.9 | 5.8 |
|  | 4 | 305 | 9 | 20 | 334 | 2.7 | 6.0 | 8.7 |
| 1983 | 0 | 154 | 86 | 4 | 244 | 35.2 | 1.6 | 36.9 |
|  | 1 | 172 | 111 | 13 | 296 | 37.5 | 4.4 | 41.9 |
|  | 2 | 313 | 71 | 13 | 397 | 17.9 | 3.3 | 21.2 |
|  | 3 | 323 | 41 | 21 | 385 | 10.6 | 5.5 | 16.1 |
|  | 4 | 347 | 18 | 36 | 401 | 4.5 | 9.0 | 13.5 |
| 1984 | 0 | 130 | 119 | 1 | 250 | 47.6 | 0.4 | 48.0 |
|  | 1 | 147 | 134 | 8 | 289 | 46.4 | 2.8 | 49.1 |
|  | 2 | 274 | 105 | 36 | 415 | 25.3 | 8.7 | 34.0 |
|  | 3 | 267 | 56 | 46 | 369 | 15.2 | 12.5 | 27.6 |
|  | 4 | 319 | 20 | 45 | 384 | 5.2 | 11.7 | 16.9 |
| 1985 | 0 | 97 | 135 | 8 | 240 | 56.3 | 3.3 | 59.6 |
|  | 1 | 156 | 171 | 12 | 339 | 50.4 | 3.5 | 54.0 |
|  | 2 | 274 | 101 | 45 | 420 | 24.0 | 10.7 | 34.8 |
|  | 3 | 269 | 79 | 66 | 414 | 19.1 | 15.9 | 35.0 |
|  | 4 | 268 | 42 | 64 | 374 | 11.2 | 17.1 | 28.3 |
| 1986 | 0 | 127 | 133 | 8 | 268 | 49.6 | 3.0 | 52.6 |
|  | 1 | 152 | 191 | 20 | 363 | 52.6 | 5.5 | 58.1 |
|  | 2 | 243 | 134 | 71 | 448 | 29.9 | 15.8 | 45.8 |
|  | 3 | 263 | 77 | 105 | 445 | 17.3 | 23.6 | 40.9 |
|  | 4 | 277 | 28 | 122 | 427 | 6.6 | 28.6 | 35.1 |
| 1987 | 0 | 125 | 156 | 6 | 287 | 54.4 | 2.1 | 56.4 |
|  | 1 | 170 | 207 | 36 | 413 | 50.1 | 8.7 | 58.8 |
|  | 2 | 268 | 153 | 76 | 497 | 30.8 | 15.3 | 46.1 |
|  | 3 | 255 | 104 | 121 | 480 | 21.7 | 25.2 | 46.9 |
|  | 4 | 251 | 32 | 179 | 462 | 6.9 | 38.7 | 45.7 |
| $\begin{array}{r} 1982 \\ -87 \end{array}$ | 0 | 806 | 684 | 32 | 1,522 | 44.9 | 2.1 | 47.0 |
|  | 1 | 1,065 | 861 | 110 | 2,036 | 42.3 | 5.4 | 47.7 |
|  | 2 | 1,725 | 596 | 252 | 2,573 | 23.2 | 9.8 | 33.0 |
|  | 3 | 1,718 | 364 | 373 | 2,455 | 14.8 | 15.2 | 30.0 |
|  | 4 | 1,767 | 149 | 466 | 2,382 | 6.3 | 19.6 | 25.8 |

Data estimated by prorating "unknown restraint type" across known types and "unknown whether or not restrained" across other restraint categories within accident year and individual year of occupant age
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