

ESTIMATING THE LIVES SAVED BY SAFETY BELTS AND AIR BAGS

Donna Glassbrenner

National Center for Statistics and Analysis
National Highway Traffic Safety Administration
Washington DC 20590
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ABSTRACT

We present a nontechnical discussion of changes made to the calculations of the lives saved by safety belts and air bags published by the National Highway Traffic Safety Administration (NHTSA). Each year when new data are available from the Fatality Analysis Reporting System, NHTSA's National Center for Statistics and Analysis (NCSA) estimates the numbers of passenger vehicle occupants, ages 5 and older, that were saved by safety belts and air bags during that year. NCSA also estimates the number of people that would have been saved if belt use had been at various higher use rates.

Substantial changes are made to these calculations. They are corrected to properly recognize the combined effectiveness of safety belts and air bags, and to remove children under the age of 13 from the calculation of the

lives saved by air bags. We examine the method currently used to parcel the total savings by belts and bags into those saved by belts and those by bags, and delineate the range of possible belt-bag attributions. Finally, we choose a consistent method for all calculations hypothesizing a higher belt use. Our choice will slightly change the interpretation of the number of lives that would have been saved if everyone had buckled up, but this change of interpretation is necessary to have consistent estimates.

The new methods will change some estimates substantially and so revisions will be issued for prior data years. We specify how these will be calculated. We also discuss the updated effectiveness ratings and belt use model that will be implemented simultaneously with the new methods.

INTRODUCTION

Safety belts and air bags have made our roads substantially safer over the years. NHTSA estimates that safety belts have saved 147,246 lives in the period 1975-2001, and air bags saved 8,369 lives

between 1987 and 2001. Figure 1 displays the savings in the period 1991-2001, during which about 109,000 lives were saved by belts and 8,000 by air bags.

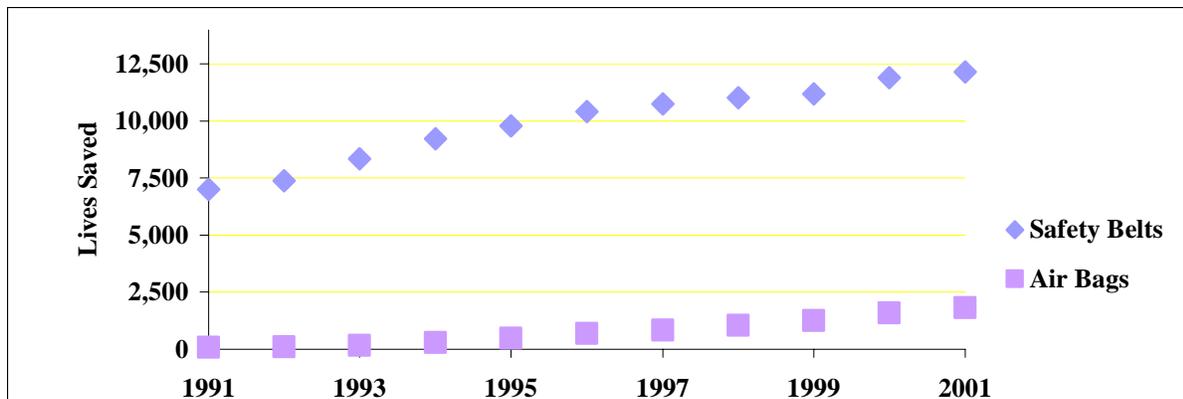


Figure 1. Lives Saved by Safety Belts and Air Bags

Since children under the age of 5 should be in a child safety seat, the lives saved by safety belts only reflects occupants ages 5 and older. Similarly, since children under 13 should not be in front of an air bag

unless there is no other seat available, the lives saved by air bags reflects occupants ages 13 and older.

Of course, lives saved cannot simply be counted, but must instead be estimated based on the numbers of

fatalities and the known effectiveness of belts and air bags. That is, we infer the number of those who did not die from those who died while using the safety device and the effectiveness of the device. In this paper, we present recent changes we made to the methodology used to estimate these lives saved and those that would have been saved if a higher proportion of occupants had used belts. We do not

provide formulas or other technical details here, but these may be found in [G].

NHTSA also calculates variations on these lives saved estimates, such as the numbers of lives lost from not wearing safety belts or the number that would be saved at some particular point in the future (with a projected belt use), that should incorporate changes similar to those in this paper.

1. HOW THE SAVINGS ARE CALCULATED, AND OUR MODIFICATIONS

Lives saved are estimated from the numbers of fatalities, which NHTSA collects in its Fatal Analysis Reporting System (FARS), and from the effectiveness ratings of safety belts and air bags, which NHTSA periodically recalculates to reflect changes in technology and the types of crashes

occurring on the roads. We will illustrate our nontechnical description with a small example, namely drivers in the year 2000 in passenger cars equipped with three-point belts, which had the following fatalities and effectiveness ratings.

Table 1.
Fatalities and Effectiveness Ratings in 2000 for Drivers of Passenger Cars with 3-Point Belts

| Belt Used? | Air Bag in Vehicle? | Age 5-12? | Effectiveness of Restraint Used | Fatalities |
|------------|---------------------|-----------|---------------------------------|------------|
| Yes | Yes | No | 53.72% | 3,565 |
| No | Yes | No | 14% | 3,364 |
| Yes | Yes | Yes | 48% | 0 |
| No | Yes | Yes | 0% | 1 |
| Yes | No | No | 48% | 2,008 |
| No | No | No | 0% | 2,893 |
| Yes | No | Yes | 48% | 0 |
| No | No | Yes | 0% | 2 |

Source: National Center for Statistics and Analysis, NHTSA, 2000 FARS and [K2], [RC]

For instance, 2,008 people over the age of 12 and belted with a 3-point belt died in crashes driving passenger cars that didn't have driver's side air bags. These 3-point belts are 48% effective against fatality, meaning that they reduce the fatalities among those who would die unbelted and without an air bag by 48%.

of SUV rollovers). The data year 2002 will be the first that uses the ratings from [K2], [M], and [RC]. When the 2002 estimates are published, estimates from prior data years will be revised in a manner that gradually incorporates the transition from the ratings in [K1] to those in [K2], [M], and [RC].

These effectiveness ratings, which are the most recent available, were calculated by NHTSA in [K2] and [RC]. The most recent effectiveness ratings in the rear seats are found in [M]. Prior to the 2002 data year, ratings from [K1] were used. The new ratings reflect changes in belt technology, newer vehicles (e.g. greater numbers of sport utility vehicles (SUVs)), and changes in the types of crashes occurring on the roads (e.g. the increased incidence

Because air bags are passive restraints, their effectiveness ratings reflect the protection provided by the air bag's *presence*, not its *deployment*. Note also that the effectiveness of a belt-bag system is somewhat less than the sum of the effectiveness ratings of its two components, i.e. $53.72\% < 48\% + 14\%$. That is, belts and bags have what is known in statistical terminology as a *negative interaction*.

Correcting the Use of the Joint Effectiveness of Belts and Bags

It is a relatively straightforward matter to estimate the number of lives saved by belts and bags combined. If

x people die using a safety device that has an effectiveness e (i.e. that reduces fatalities in settings

in which people would otherwise die by $e \times 100\%$), then one can infer that a total of $x/(1-e)$ used the device in a setting in which they would otherwise die, $ex/(1-e)$ of which were saved by the device. Applying this to each line of Table 2 gives that 6,540

drivers in passenger cars equipped with 3-point belts were saved in 2000. We corrected an oversight in the implementation of this calculation, concerning the manner in which the effectiveness of combined belt-bag systems was incorporated.

Table 2.
Lives Saved in 2000 for Drivers of Passenger Cars with 3-Point Belts

| Belt Used? | Air Bag in Vehicle? | Age 5-12? | Effectiveness of Restraint Used | Fatalities | Lives Saved by Belts and Bags |
|--------------------------|---------------------|-----------|---------------------------------|------------|-------------------------------|
| Yes | Yes | No | 53.72% | 3,565 | 4,138 |
| No | Yes | No | 14% | 3,364 | 548 |
| Yes | Yes | Yes | 48% | 0 | 0 |
| No | Yes | Yes | 0% | 1 | 0 |
| Yes | No | No | 48% | 2,008 | 1,854 |
| No | No | No | 0% | 2,893 | 0 |
| Yes | No | Yes | 48% | 0 | 0 |
| No | No | Yes | 0% | 2 | 0 |
| Total Lives Saved | | | | | 6,540 |

Source: National Center for Statistics and Analysis, NHTSA, FARS, 2000

Attributing the Joint Savings to the Belt and Bag Components

NHTSA wishes to parcel out this total savings to belts and bags separately, and this requires making choices. The 1,854 people saved in Table 2 who did not have air bags were clearly saved by their belts, and similarly, it is more reasonable to say that the 548 unbelted saved people were saved by their bag. (We ignore the fact that we cannot say with certainty that the air bag deployed in all 548 cases.) However, for the 4,138 who were saved using both a belt and a bag, we cannot say which restraint component saved them. It is clearly unfair to attribute all 4,138 to one component, since neither component could have

saved this many. E.g. these belts are only 48% effective and so could only have saved at most 3,697 people (that is, $.48 \times 3,565 / (1 - .5372) = 3,697$). Similarly, bags could have saved at most 1,078 people. However, any partitioning between 3,697 belts, 441 bags and 3,060 belts, 1,078 bags is a reasonable attribution. NHTSA's current methodology is to use the attribution that favors belts the most (i.e. 3,697 saved by belts and 441 by bags) because air bags are viewed as restraints that supplement safety belts.

Correcting the Incorporation of Children in the Air Bag Calculations

Children under the age of 13 should not be placed in front of an air bag unless there is no other seat available. Because of this and because NHTSA has found the available data to be insufficient to derive reliable air bag effectiveness ratings for these children, air bags are rated as 0% effective against fatality for occupants under 13. For example, the restraint (i.e. the air bag) used by the one unbelted child between 5 and 12 years in row 4 of Table 2 has an effectiveness rating of 0% for this child, instead of the 14% used in row 2 for occupants over 12.

Similarly, had there been any belted children between 5 and 12 years in row 3 of Table 2, they would have been using a restraint system (i.e. a belt and bag) that is 48% effective for them, rather than the 53.72% used in row 1 for drivers over 12. In programming the calculation described in this paper, we corrected an oversight in the implementation of the currently used calculation that incorrectly applies the effectiveness ratings for occupants over 12 to occupants ages 5-12.

Making the Calculations Involving Hypothetical Use Consistent

NHTSA also estimates the number of people that would have been saved if belt use had been higher

(e.g. the number that would have been saved if belt use had been 90% in 2000). There are two

reasonable ways that one could estimate such quantities. In this paper we will refer to these methods as the “Average Effectiveness” and “Individual Effectiveness” methods. These are difficult to describe without giving technical details, which can be found in [G], but the basic difference between the two is that the “Individual Effectiveness”

method uses the individual effectiveness ratings of the several types of belts, while the “Average Effectiveness” method uses an average effectiveness rating. These methods would have given the following estimates of the number saved among drivers of passenger cars with 3-point belts if belt use had been 90% in 2000.

Table 3.
Lives That Would Have Been Saved in 2000 for Drivers of Passenger Cars with 3-Point Belts if 90% of Them Had Used Belts

| Method Used for Calculation | Lives That Would Have Been Saved |
|-----------------------------------|----------------------------------|
| “Average Effectiveness” Method | 8,046 |
| “Individual Effectiveness” Method | 8,163 |

Source: National Center for Statistics and Analysis, NHTSA, FARS, 2000

The difference in the two methods is fairly small in this example (about 1%), but is a little larger in general (about 5%).

NHTSA had previously used different methods in different settings (e.g. for 90% use, 100% use, or use that is one percentage point higher), and this resulted in inconsistent estimates. Since both the “Average Effectiveness” and “Individual Effectiveness” methods are intuitively correct, but the “Average Effectiveness” Method is easier to implement, we chose it as the methodology to use for all calculations of the lives that would have been saved at higher belt use rates.

Of course, the question of which component the additional savings should be attributed to also exists here. The analog of NHTSA’s belt-favoring approach from the previous section is to attribute all of the additional 8,046 savings to belts (and none to bags). This has the consequence that buckling up doesn’t make the bag work better (although this could be viewed as an unappealing property, since in reality, buckling up positions the occupant for the air bag to work optimally).

This calculation also uses a model of safety belt use among potential fatalities (those who would have

died if they had been unbelted and with no air bag) as a function of daytime use in the front seat. (The latter is a convenient quantity to model on, since it is estimated every year in NHTSA’s National Occupant Protection Use Survey. [N]) Prior to the 2002 data year, the model from [WB1] was used. NHTSA updated this model in [WB2] to reflect recent changes in belt use. Starting in the 2002 data year, the updated model from [WB2] will be used in the lives saved calculations (specifically, in the calculations of the lives that would have been saved at a higher belt use rate), unless a yet new model is available at that time. Revisions will also be issued for prior years that gradually incorporate the transition from the model in [WB1] to the new model.

Choosing a consistent methodology forced us to change the interpretation of the savings at 100% belt use. The previous calculation estimated the number saved if ALL occupants had belted themselves. The new calculation amounts to estimating the number saved if belt use had been 100% among occupants of the front seat in daylight hours. Consequently, the new estimate is lower than the older, but had to be in order to be consistent with the other calculations that hypothesize a belt use rate.

2. IMPLEMENTING THESE CHANGES

All changes in the previous section will be applied in the 2002 data year. In addition, revisions will be issued for the estimated lives saved in previous years that gradually incorporate the transition to the new methodology.

There is no canonical choice for how far back revisions should be calculated. Some of the changes in the previous section are methodological

corrections that are valid for all years (such as the correct use of the joint belt-bag effectiveness and the removal of children under 13 from the air bag savings). Other changes reflect recent changes on the roads and so should only be applied to a limited number of years. E.g. the new effectiveness ratings from [K2], [M], and [RC] largely reflect the increased presence of SUVs that started in the early 1990s, while the model of use among the potential

fatalities in [WB2] reflects recent changes in belt use. However since the corrections in the joint effectiveness and the removal of children have little

effect prior to the 1990 data year, when air bags were less prevalent, we plan to issue revisions for the lives saved since the 1990 data year.

3. FUTURE WORK

NHTSA is currently updating its model of use among potential fatalities as a function of daytime use in the front seat from [WB2] to reflect the updated effectiveness ratings from [K2], [M], and [RC]. We plan to incorporate this model when it is available.

Also, modifications similar to those in this paper could be made to the calculations of injuries prevented from the use of safety belts or sustained from not using belts. We plan to revisit the methodologies currently used in these injury calculations.

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