

## Road crash costs

### Summary

Road crashes result in all kinds of social costs, such as medical costs, production loss, human losses, property damage, settlement costs and costs due to congestion. Studies into road crash costs and their trends are carried out quite regularly. In 2003, the most recent year in which these costs were examined in the Netherlands, the costs amounted to € 12.3 billion, or 2.6% of the Gross Domestic Product (GDP). A preliminary calculation indicates that the costs in 2009 were € 13 billion and that they make up 3% of the GDP. Insight into these costs is used for policy preparation and evaluation, and makes it possible to compare them with costs in other areas. Another important application is the use in cost-benefit analyses which use the costs per crash or casualty saved to assess road safety investments. The method for the research into road safety costs has improved considerably over the years, for example by also including human losses.

### Background and content

In 2009, there were 720 fatalities in the Netherlands, and 18,580 serious road injuries. In addition, each year a much larger average annual number of crashes results in less severe injury or leads to property damage only (PDO). This results in all sorts of social costs, such as medical costs and production loss. Improving road safety has priority in mobility policy, mainly because of such social costs (VenW, 2008). Both in the Netherlands and in other countries research is regularly carried out into the size of these crash costs as well as into cost trends. The first study in the Netherlands was done in 1985 (McKinsey, 1985). Commissioned by the Transport Research Centre (AVV) in the Netherlands, SWOV carried out the first update of this study in 1995, in which various aspects of the method were improved (Muizelaar et al., 1995). Since then, SWOV and the Centre for Transport and Navigation (DVS, previously called AVV) periodically study the costs of crashes in the Netherlands. Over the years the method has been improved further, for example, by including human losses and congestion due to crashes. Similar developments also took place in other countries.

### What is the purpose of road crash costs research?

Information about the size and development of road crash costs is important to policy and research for two reasons. Firstly, this information is regularly used to prepare and assess the national road safety policy, like the realization of the *Mobility Policy Document* (VenW & VROM, 2004). The information is also useful for comparing costs of road crashes with costs in other policy areas. These can be other sectors within traffic and transport or sectors in other areas, for example environmental policy, public health or other sectors concerned with safety policy. Information about the social costs provides insight into the possibilities for cost reduction and can be used for setting policy priorities. International comparisons of road crash costs are also made.

Secondly, information about the costs of road crashes is used in cost-benefit analyses (see SWOV Fact sheet [Cost-benefit analysis of road safety measures](#)). These analyses use the costs per crash or per casualty to express the road safety policy effects in terms of money. For example, the guideline Overview Effects Infrastructure (OEI), a guideline often used for cost-benefits analyses in the Netherlands, uses core road crash cost data (Eijgenraam et al., 2000). Research into the costs of road safety is also carried out to determine prices for mobility. Estimates of traffic costs estimates are used to determine the extent to which current pricing policy is efficient and which improvements are possible. Studies carried out by CE Research and consultancy (CE, 2004) and the European Conference of Ministers of Transport (ECMT, 1998) investigate this subject. These studies also examined other traffic costs than those of crashes, more particularly costs of infrastructure, environment and congestion.

### Which types of costs are there and how should they be measured?

In 1994, an extensive international comparative study was published about the way in which 14 European countries determine the costs of traffic crashes: the COST 313 project (Alfaro et al., 1994).

The report made recommendations about the categories of costs that should be studied and how the costs in each category should be measured. In brief (Elvik, 1997), this resulted in five main categories, each with its own measuring methods:

1. *Medical costs*. These result from the treatment of casualties, e.g. costs of hospital, rehabilitation, medicines and adaptations for the handicapped. These costs must be determined by the 'restitution costs method'. All countries do this in practically the same way.
2. *Production loss*. These costs result from the temporary or permanent disability of the injured, and the complete loss of production of fatalities. These costs have to be determined by the 'human capital method', which determines the value of the production that would have been realised by the casualties if they had not been injured or killed. This is also done in more or less the same way in all countries. However, important differences can occur: some countries also put a value on domestic work, some countries correct the production loss of fatalities for their consumption loss, and there are various assumptions regarding the growth of incomes. (Elvik, 1995; Trawén et al., 2002).
3. *Loss of quality of life* of casualties and their families and friends ('human costs' or 'human losses'). These are the immaterial costs through suffering, pain, sorrow and loss of the joy of living. It is recommended to determine these costs with one of the 'willingness-to-pay methods'; these methods determine the amount of money people are prepared to pay to prevent human suffering. In general, most countries recognize this cost category, but the calculation methods differ widely, and only a few countries use a willingness-to-pay method. The willingness to pay for a reduction in the chance of dying also includes the economic value of consumption loss. If this is also part of the production loss, the willingness-to-pay must be corrected to avoid counting it twice.
4. *Property damage*. These costs result from damage to goods such as vehicles, freights, roads and fixed roadside objects. For this the 'restitution costs method' is recommended. This is used in the same way everywhere.
5. *Settlement costs*. These costs result from the settlement of crashes and the resulting expenses incurred by organizations such as the fire brigade, police, law courts and insurers. Also for these costs the 'restitution costs method' is recommended. This is already generally used.

This situation in 1994 is mainly the result of developments in the knowledge about valuing 'imponderables': cost elements for which there are no market prices. Elvik (1995) distinguishes four phases in the developments since the 1950s: it was only during the last phase in the 1980s that a number of countries began to value 'human losses' based on a willingness-to-pay method. This approach is, theoretically, very well justifiable. However, empirical research into the willingness to pay for traffic risk reduction is complicated and provides results with many uncertainties. Since 1994 an increasing number of countries nevertheless use a willingness-to-pay method (see SWOV Fact sheet [The valuation of human losses of road deaths](#)). This was sometimes accompanied by improvements in this method.

### **How are the crash costs measured in the Netherlands?**

Nowadays, SWOV and DVS carry out the crash costs research according to the recommendations of the COST 313 report in practically all aspects. A sixth category was added: the costs resulting from congestion; these costs are caused by loss of time due to traffic-jams resulting from crashes. In the Netherlands, the 'real' numbers of crashes and casualties are used, i.e. allowing for those crashes and casualties that were not registered.

1. *Medical costs*. Various data sources are used to determine these costs, including data from Statistics Netherlands (CBS) and the National Medical Register (LMR). The latter contains, for example, the average number of days that a casualty is hospitalized, the average costs per day of hospital or nursing home treatment and the annual number of ambulance trips.
2. *Production loss*. The potential loss of production is calculated, i.e. the monetary value of the contribution somebody would have made if he or she had not been injured or killed. Here, it does not matter if the individual casualties actually were employed before the crash, or would have been employed in the future. In the case of fatalities, the total value of the production over the lost productive years is estimated and the present value is calculated, i.e. the production is weighed over those lost years. As yet, no allowance has been made for unpaid work, such as domestic or voluntary work. However, the consumption loss of fatalities is included in the production costs.
3. *Loss of quality of life*. To determine the human losses a survey was held in the Netherlands about the amount of money people are willing to pay for a certain reduction in crash rate (De Blaeij, 2003). This study determined the so-called 'Value Of a Statistical Life' (VOSL) which is used to calculate the human losses. The VOSL is corrected for the consumption loss of those killed,

because these costs have already been included in the category production loss (Wesemann et al., 2005).

So far little is known about the human losses as a result of non-fatal injury; such a study has only been carried out in Great Britain (Hopkin & O'Reilly, 1993). Based on this, the human losses per in-patient are estimated at 10% of those of a fatality.

4. *Property damage*. The estimation of these costs is based on insurance data, such as damage claims paid, and estimates of the damage not claimed and the damage not covered by third party policies.
5. *Settlement costs*. CBS statistics and insurance data are among the sources used to estimate these costs.
6. *Congestion costs*. Research data into the total traffic jam costs and the share of lost time due to crashes is used to estimate these costs. This share was in 1997, the last year for which the sum was calculated, about 13% (NEA, 1998). For more recent years this share is corrected for the development of the 'congestion weight' (length of traffic jams multiplied by their duration). According to this method the share was 14% in 2003 (AVV, 2006).

In the Netherlands, research has also been done into prevention costs, such as those for infrastructural measures, enforcement, vehicle safety and research (Wijnen & Stroeker, 2009). They are, however, not included in crash costs, as they are meant to prevent crashes.

### How high are the crash costs in the Netherlands?

#### *Research results over the year 2003*

In 2003, the last time such research was carried out, the total crash costs amounted to € 12.3 billion. The largest categories in 2003 were human costs (€ 5.5 billion), and material costs (€ 3.8 billion), whereas the production loss and settlement costs (each € 1.3 billion) also had a large share (see *Table 1*).

Cost category	1997	2000	2003
Medical costs	182	192	232
Property damage	2,647	3,250	3,866
Settlement costs	834	1,055	1,262
Production loss	1,290	1,441	1,294
Congestion costs	88	100	125
Human costs	5,206	4,957	5,549
Total	10,248	10,995	12,327

Table 1. *Social costs of road crashes (€ million, current prices)*. Source: AVV, 2006.

Between 1997 and 2003, the costs rose by 20%. However, if an inflation correction is made, the increase in costs is extremely limited: 1%. There are large differences between the various cost categories. The settlement costs and material costs rose by 50% because of, among other things, the rise in the price of new cars. The production loss initially increased, but between 2000 and 2003 it declined again as a result of a declining inflow of traffic casualties into the Disablement Insurance Act, and an increase in the number of diagnoses of partial disability. The human losses increased relatively little because of a reduction of the number of casualties (AVV, 2006).

It is also known how the costs are distributed among casualty and crash severities, and how much the costs are per casualty or crash (AVV, 2006; see also *Table 2*). The majority of the costs can be attributed to crashes resulting in in-patients (€ 4.7 billion), PDO crashes (€ 3.9 billion) and, to a lesser extent, the road deaths (€ 2.6 billion). The costs of crashes with Accident & Emergency (A&E) patients or casualties with less severe injuries are relatively low (€ 0.8 billion and € 0.4 billion respectively). The costs per fatality were by far the highest (€ 24 million), especially because the immaterial costs weigh heavily in that.

Casualty severity	Number of casualties		Costs		Costs per casualty	
Fatalities	1,088		2,640		2.427	
In-patients	18,600		4,655		0.249	
A&E patients	97,000		767		0.008	

Table 2. *Number of casualties, and costs by crash severity and per casualty in 2003 (in € million),. Source: AVV, 2006.*

*Update: an estimation for the year 2009*

No study has been made of the costs in more recent years. Based on the casualty numbers in 2009, the costs per casualty and the inflation figures, we can give an indication of the costs in 2009. For that year *Table 3* shows the number of deaths, in-patients and A&E patients. Notice that a new definition 'serious road injury' is used (casualties with injuries equal to or exceeding MAIS2), instead of in-patients. However, since no research has yet been done into the costs per so-called serious road injury (MAIS2+), for now we will use the number of in-patients according to the definition used in the study of the 2003 costs. 2007 is the latest year for which this number of in-patients is known. We estimate the number of 2009 in-patients by raising the number of in-patients in 2007 (18,190) by the increase of the number of hospitalizations of road casualties between 2007 and 2009 according to the LMR (13.6%). This results in a number rounded off to 21,000 in-patients. The number of A&E casualties in 2009 is estimated at around 105,000 on the basis of the Dutch Injury Information System (LIS). The numbers of casualties were then multiplied by the costs per casualty from *Table 2*. Furthermore, an inflation correction was carried out using the price development (deflators) of the GNP which is published by Statistics Netherlands. As insufficient reliable data about the real number of casualties and PDO crashes was available, the costs of less serious injury and PDO crashes were calculated by correcting those costs in 2003 for inflation only. According to this calculation, the total costs in 2009 amount to approximately € 13.1 billion (*Table 3*). The decline in the number of fatalities, which was even a rapid decline in some of the recent years, has therefore not led to a decrease in costs. The most important reason for this is that the number of in-patients, which constitutes a large part of the total costs, has increased.

Crash severity	Number of casualties	Costs (€ billion)
Fatal	720	1.9
In-patients	21,000	5.6
A&E	105,000	0.9
Light injury	Unknown	0.4
MDO	Unknown	4.3
<b>Total</b>	Unknown	<b>13.1</b>

Table 3. *Number of casualties and crash costs by crash seriousness in the Netherlands, 2009.*

In cost-benefit analyses, the costs per casualty are used to express safety measures in an amount of money. An amount per death is sometimes used to make a rough estimation, in which the costs of (all) casualties and PDO crashes are also included. This amount (€ 18 million per death in 2009) is calculated by dividing the total costs of road crashes (€ 13.1 billion) by the amount of deaths (720). However, this is a very rough estimation, because only the effect on the number of deaths is taken into account, not the deviating effects on injuries and PDO crashes. For this reason, SWOV has, together with DVS, fine-tuned the method, among other things with the purpose of supplementing the OEI guideline for (road) safety. This fine-tuned method distinguishes deaths and serious road injuries. The costs per death are used (€ 2.6 million, price level 2009) as well as an amount per serious road injury (€ 0.6 million in 2009). In the latter amount, the costs of light injury and PDO crashes are also included. The amount is calculated by dividing the total costs of (all) injuries and PDO crashes (€ 11.2 billion) by the number of serious injuries (18,580). These figures can be applied in a cost benefit analysis if the effects on the number of deaths as well as on the number of serious injuries are known. SWOV recommends to only apply this method when time and money for a cost-benefit analysis of all measures are lacking.

In 2003 the costs of road crashes amounted to 2.6% of the Gross Domestic Product (GDP). Working with the above calculation of € 13.1 billion in costs in 2009, this was 2.3% in 2009. A comparison with other social costs also gives insight into the relative magnitude of the amount. The Netherlands Institute for Transport Policy Analysis (KiM, 2009) estimates the costs due to congestion on the main road network at €2.8 to 3.6 billion in 2008. These are the costs due to direct loss of travel time and unreliability of travel times, costs that are caused by people adapting their behaviour to traffic jams (detour, another time of day, etc.), extra fuel costs, and indirect costs like the effects on public transport. The environmental costs of road traffic are estimated at €2.0 billion to €8.5 billion (KiM, 2009). These are the costs of air polluting emissions, CO<sub>2</sub> emissions and noise nuisance. Therefore, the road crash costs are high compared with other traffic related costs.

### **What are the results of international comparison?**

Many countries do research into crash costs and there are various international comparative studies. A sound comparison requires sufficient knowledge about the following issues: Have the same cost categories been studied? Have the same measuring methods been used? Is the data used of comparable quality?

The COST 313 study provides outline answers to the first two questions. With exception of the human losses and their measuring methods, the fourteen countries used the same cost categories and measuring methods. In spite of this, determining the production loss (by valuing unpaid work and correction for consumption loss of those killed) can still result in large differences (Elvik, 1995). COST 313 did not answer the question whether the data was of a comparable quality. Answering this question is practically impossible because of the large number of divergent sources used for these studies. However, one of the comparative studies (Elvik, 2000) investigated whether the cost estimates referred to all crashes, i.e. also property damage only crashes and crashes not registered in official statistics. In the light of all this, the results of international comparisons must be used carefully. In addition, a distinction should at the very least be made between the countries that do and those that do not include human losses.

Elvik (2000) compared the costs of eight European and four non-European countries. All these countries had estimated human losses in one way or another. The data of the eight European countries referred to one single year in the 1990-1997 period. For these countries their costs, including human losses, varied from 1.3% to 3.2% of the Gross Domestic Product (an average of 2.1%). Excluding human losses, this was 0.5% to 2.8% (an average of 1.3% of the GDP).

Trawén et al. (2002) studied the costs per fatality in nine European and two non-European countries. They indicate that the average costs in these countries had increased by about 70% in the period 1990-1999. This increase can for example be attributed to changes in calculation methods and adding cost categories such as human losses. Although the costs and methods that are included increasingly resemble each other, large differences remain between the estimates in the different countries. This is illustrated by an overview of costs per casualty in ten European countries that was made in the *Road Safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision-Making* (ROSEBUD) project (Hakkert & Wesemann, 2005). For the five countries (other than the Netherlands) that included human losses, the costs per fatality ranged between more than € 1.9 million in Switzerland to € 3.0 million in Norway (price level 2002). The costs per seriously injured casualty ranged between € 169,000 (Switzerland) to € 474,000 (Norway).

### **Will there be continued research?**

Together with SWOV, the Netherlands Institute for Transport Policy Analysis (KiM), Statistics Netherlands and the Consumer Safety, the Dutch Centre for Transport and Navigation (DVS) has recently started a study into the road crash costs in 2007. Where necessary and possible, attention shall be given to methodological improvement, for example in determining the costs of serious injuries. A supplement to the OEI guideline which describes how safety should be included in a cost-benefit analysis of infrastructure projects will soon be published. This supplement will make recommendations about valuing road safety effects based on crash cost data.

### **Conclusions**

In 2003, the road crash costs in the Netherlands were € 12.3 billion, or 2.6% of the Gross Domestic Product. At the moment, research is being done into more recent years. A preliminary calculation (based on the costs per casualty in 2003, inflation correction and the number of casualties in 2009)

shows the costs in 2009 to be about € 13 billion and a 2.3% share of the GDP. Insight in these costs is important for preparing and assessing (road safety) policy. The research methods into crash costs have improved considerably over the years, for example, by also including the human losses due to death and injury.

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