# Is law enforcement of drug-impaired driving cost-efficient?

## An explorative study of a methodology for cost-benefit analysis


## ABSTRACT

Background

Road-users driving under the influence of psychoactive substances may be at much higher relative risk in road traffic than the average driver. Legislation banning blood alcohol concentrations above certain threshold levels combined with roadside breath-testing of alcohol have been in lieu for decades in many countries, but new legislation and testing of drivers for drug-use have recently been implemented in some countries.

Methods

In this article we present a methodology for cost-benefit analysis of increased law enforcement of roadside drug screening. This is an analysis of the profitability for society, where costs of control are weighed against the reduction in injuries expected from fewer drugged drivers on the roads. We specify assumptions regarding costs and the effect of the specificity of the drug screening device, and quantify a deterrence effect related to sensitivity of the device yielding the benefit estimates.

Results

The methodology was tested for three European countries: the Netherlands, Belgium, and Finland. It was indicated that increased enforcement is most profitable in the Netherlands and least in Finland, which was logical since in Finland the baseline enforcement level was considerably higher than in the Netherlands. In the Netherlands, even multiple increases of enforcement might be cost efficient.

Conclusions

The applied exploratory methodology for cost-benefit analysis clearly indicated that the cost-efficiency of increased law enforcement of drug driving offences is mainly dependent on the baseline situation of drug-use in traffic and on the current level of enforcement, as well as on the prevalence and relative risk of different drugs.



Key words: drugs, economics, oral fluid, screening

# Introduction

Driving under the influence of psychoactive substances (illicit drugs and certain medicines / licit drugs, in addition to alcohol) increases the risk of accidents and casualties in road transport (Vaa, 2003; Mathijssen & Houwing, 2005; Kelly *et al.*, 2004; Peck *et al.* 2008; Hels *et al.*, 2011). Under current regulatory systems in the EU and in many other countries, there are legal limits for blood or breath alcohol concentrations of drivers, and roadside breath tests for alcohol have been carried out for decades. However, law enforcement when caught driving under the influence of drugs has been complex because of the absence of practical and reliable detection devices (Christophersen *et al.*, 1999; Smink *et al.*, 2001; Marc & Mura, 2005; Kuijten, 2009). Devices based on oral fluid sampling have become available only relatively recently (Maes *et al.*, 2003; Verstraete & Raes, 2006; Drummer *et al.*, 2007; Verstraete & Labat, 2009).

Testing road-users for drug-use, however, is relatively expensive and time-consuming compared to alcohol-testing (Blencowe *et al.*, 2010; Kuijten, 2009). Moreover, the alcohol-related road toll is greater than the drug-related (Isalberti *et al.*, 2011). To our knowledge, no studies have been conducted assessing the costs and benefits of stricter law enforcement of drug driving.

In this paper we develop a methodology for (societal) cost-benefit analysis (CBA) of drug driving and law enforcement. We weigh the costs to society of CBA against the injury-reduction benefits from fewer drugged drivers on the roads. To carry out a CBA, we needed data on the effects of enforcement, i.e. the expected reduction in the number of accidents; the costs of control activity; and the time-use of drivers resulting from the control. One main purpose of our paper was to present a methodology modelling any deterrence effect, and thereby accident reduction, from enforcement of the law. A similar analysis of drivers under the influence of psychoactive substances has been presented by Elvik (2001).

Using CBA we assess the degree to which (increased) road-side screening of drug driving offences is profitable in economic terms for society. We assess changes from a reference level (current control level), as CBA normally involves *ex ante* assessment of a change (Mishan, 1988). The policy goal of increased enforcement, i.e. targeting drivers under the influence of psychoactive substances, would be to increase societal benefits (reduce societal costs) through a deterrence effect that would reduce the number of people driving under the influence of psychoactive substances, and subsequently the toll of fatalities and injuries (Shoup, 1973; Evans *et al.*, 1991; Kuijten, 2009). We include a cost-effectiveness analysis (CEA) estimating the cost per conviction as

cost-effectiveness ratio. We estimate benefit-cost and cost-effectiveness ratios of increased law enforcement of psychoactive substances in the Netherlands, Belgium and Finland.

The remainder of the paper is arranged as follows: In the next section we describe the methodology of CBA and the specific assumptions applied, and in the third section the database for prevalence of psychoactive substances, reference enforcement/control level, injury/fatality data and valuations, and cost data for three EU countries: the Netherlands, Belgium and Finland. The fourth section presents the results of the data analysis, including a comprehensive simulation-based uncertainty analysis of estimated benefit-cost ratios. Our findings are discussed and concluded in the final section.

# Theories and methods

## A CBA model

CBA applied to a proposed road safety policy measure answers the question about the economic efficiency of the measure. If several road safety measures are compared, a CBA will indicate which (combination of) measure(s) provides the greatest difference between benefits and costs (Hakkert & Wesemann, 2005). Our particular CBA should answer two questions: (*i*) the degree to which enforcement of legislation against driving under the influence (DUI) of drugs is profitable in economic terms for society; and (*ii*) which of the existing devices for enforcement are the most profitable. The following data are needed:

*a)* costs of devices/equipment;

*b)* costs of police time;

*c)* costs of laboratory analyses;

*d)* costs of the judicial system;

*e)* effects of enforcement, i.e. any reduction of accidents, fatalities, injuries and material damage resulting from this kind of enforcement;

*f)* costs of (or positive benefits of preventing) accidents, fatalities, injuries and material damage; and

*g)* costs (negative benefits) of road-user time.

The first four elements (*a* – *d*) concern the cost side of the CBA, and the latter three (*e* – *g*) the benefit side.

On the cost side there will be a cost per stopped driver, i.e. the unit cost of the drug screening device for oral fluid testing (or, in the case of alcohol, a mouthpiece for breath-testing) and police time that depends on the time consumption for device *X* (time taken collecting and analysing the sample). Prevalence at the testing site, applied on the cost side, is estimated by multiplying the overall prevalence (the average at all locations at all hours) by a constant (approximating the prevalence level when testing selectively at specific sites at specific times). Together with prevalence at the testing site, the sensitivity (detection rate of true positives) and specificity (detection rate of true negatives, and 1-specificity yields the share of false positives) of device *X* determine what share of drivers stopped will test positive, leading to additional reporting time by the police and laboratory costs. The true positives, as confirmed by laboratory testing, become part of the judicial process, which also involves costs (and this share of true positives is given from *PPV*).

Information/publicity costs related to a considerable increase in enforcement of psychoactive substance use have to be included and for some European countries also in the case of law amendments on enforcement of drug and medicine use. As with other types of road safety campaign, information/publicity is expected to have an additional temporary impact on awareness and behaviour (Erke *et al.*, 2009), in our case contributing to the increase in perceived risk of being caught when tested, i.e. the deterrence effect (Mathijssen, 2001).

The benefit side is calculated from the change in prevalence resulting from increased enforcement. The change in attributable fatalities involving drivers under the influence of various psychoactive substances is multiplied by an official valuation of a "counted fatality".[i] As indicated above, this is based on an assumption that for each fatality reduction there is an additional reduction in serious injuries, minor injuries and material damage (Despontin *et al.*, 1998). The reason for taking this approach is that data on fatalities are considered comparable between countries, while the (under)reporting of injuries may differ considerably from one country to the next (Elvik & Borger Mysen, 1999; Elvik *et al.*, 2009). Time-use of the drug screening device (or breath-testing) for drivers is counted as a negative benefit, but only for "true negative" drivers (given from *NPV*, based on prevalence, sensitivity and specificity). For "false positive" drivers, from the initial screening there will be additional time consumption costs included as negative benefits related to follow-up reporting and laboratory testing. Elements of the CBA are described below.

## CBA scenarios

We consider three main enforcement (increase) scenarios in CBA for oral fluid drug-testing – low (50%), medium (tripling) and high (tenfold) increase. A low increase level (10%) in drug screening is relevant for Finland, since the current control level is relatively high, while a higher increase level (twenty-fold increase) is relevant for the Netherlands, because the current control level is relatively low there. Since the CBA is applied to different countries, with different prevalences of different drugs/medicines, the prevalence effect, *ceteris paribus*, is taken into consideration. Regarding law enforcement of alcohol-related driving, one possible added element in the scenarios could be an adjustment in random alcohol breath-testing to maintain current enforcement levels/current resource use; that is, transferring some share of the enforcement from alcohol to drugs. We calculate a 10% reduction in alcohol-related enforcement, and present the CBA of this reduction combined with a tripling of drug-related enforcement. We include a CEA estimating the cost per

conviction as cost-effectiveness ratio. In regard to the general assumption for European CBA in transport policy, we follow Bickel *et al.* (2006), i.e. applying a project horizon of 40 years and a 3% discount rate (yielding an annuity factor of 23.81).

## CBA of deterring drivers under the influence of psychoactive substances

The policy goal in CBA of increased enforcement of the law concerning drivers under the influence of psychoactive substances is to increase societal benefits (or reduce societal costs) through a deterrence effect that reduces prevalence of impairment due to the influence of psychoactive substances, and subsequently to reduce the toll of fatalities and injuries (Shoup, 1973; Evans *et al.*, 1991; Kuijten, 2009). Implicitly, this assumes that individual behaviour is affected by the increased presence of police at the roadside and/or by word-of-mouth of people who have been tested (Ross, 1984; Jones *et al.*, 2006; Klitzner & Sole-Brito, 2002; Matsueda *et al.*, 2006).

Accidents affected by increased enforcement of the law on drug driving can be referred to as *target accidents*. In the case of general measures like drug or alcohol enforcement, this will include the fraction of all accidents in a given region/country that are attributable to people driving under the influence of psychoactive substances. This fraction can be estimated as a population attributable risk (*PAR*) (Levin, 1953; Kleinbaum *et al.*, 1982), which is estimated from the relative risk (*RR*), often via odds ratio, of driving under the influence of a (particular) psychoactive substance and the prevalence (*P*) of the (particular) psychoactive substance in the driver population.

$$PAR = \frac{P(RR-1)}{(P(RR-1))+1} \qquad (1)$$

*PAR* takes values in the range 0 to 1; we can calculate *PAR* for all psychoactive substances for which we have prevalence and relevant risk figures.

Another impact of traffic police enforcement is the imposed time-use of those stopped. We differentiate between the use of time of those that drive under the influence of psychoactive

substances, the true positives, and those that do not, the true negatives. The time-use of law-obeying drivers forced to spend time on screening is included as a negative benefit. This follows the approaches of, e.g., Stigler (1971), Mishan (1988) and Trumbull (1990) on the issue of who has standing in CBA; the negative benefits of the law-abiders should be counted, but not those of the law-offenders. In a CBA, normally the costs and benefits are stated as present values, sums of costs and benefits over a project period where future costs and benefits are discounted to be comparable to values at present. If the net present value is positive, and subsequently the benefits divided by the costs (benefit-cost ratio) is above unity, the measure is deemed economically efficient. If several measures are compared, the alternative with highest benefit-cost ratio is the best candidate for selection (Mishan, 1988).

## Deterrence effect, device quality and benefits of enforcement

In the criminology literature, cross-sectional studies show a significant deterrence effect (change in self-reported delinquency) of changes in enforcement (Nagin, 1998; Matsueda *et al.*, 2006). In rational choice theories of behaviour, including economic theory, it is assumed that subjective/perceived risk is correlated with objective risk (Becker, 1968). One way of understanding the formation of subjective risk (changes) is that these are based on prior information that is updated with new information (Nagin, 1998). In our case, it makes sense that the quality of drug screening devices, their sensitivity in detecting drugs and medicines, should influence the deterrence effect. That is, it seems unreasonable that 0% sensitivity (not detecting any drug driver, 100% false negatives) should yield the same deterrence effect as 100% sensitivity (detecting all drug drivers, 0% false negatives).[ii]

We assume that the perceived risk of being caught when driving under the influence of illegal drugs (or alcohol or medicine above a legal cut-off level) influences our intent to drive (Ross, 1984; Jones *et al.*, 2006). The subjective expected cost (*EC*) of driving under the influence (*DUI*),

possibly with the various violation/punishment levels as for alcohol BAC levels, can be stated as a function of penalty, fine or custodial sentence (*J*) and (perceived) risk of being caught (*Q*), which is also a function of the amount of psychoactive substances in the body (e.g. oral fluid):

$$EC(DUI) = Q(DUI) \cdot J(DUI) \quad (2)$$

*J* is normally measured in monetary terms (Jørgensen & Pedersen, 2005), but one might also consider a cost in embarrassment/shame (Grasmick & Bursik, 1990), at least for some, and indirect costs in terms of losing one's licence/possibility to drive, and direct and indirect costs in the case of going to prison. For risk-neutral drivers, the deterrence effect will only depend on the product of *Q* times *J* (Shavell, 1993); but for risk-averse and risk-prone drivers the particular values on *Q* times *J* also have an impact: "For a given value of *EC*, the deterrent effect for risk averse (risk prone) drivers increases the lower (higher) *J* is compared to *Q*" (cited from Jørgensen & Pedersen 2005, p. 55, with some changes in notation).

A considerable share of risk-averse drivers, as well as a sizeable share that have distorted risk perceptions, may explain the observation that the size of *Q* (the perceived risk level) seems to dominate the overall deterrence effect (*EC*). Ross (1984) argues that when the risk of being caught is 'very high', even small penalties are effective in producing deterrence, while for a "very low" risk the size of the penalty practically becomes irrelevant. Jacob (1979) stresses that increased deterrence rests on increasing risk perception. If not, punitive policies will fail. We do not endeavour to model *EC* for different (groups of) individuals in different European countries; and we disregard the particular sizes of *J* and *Q*. We consider only changes in *Q*, and use the relationship from Equation (2) that increasing *Q* for a given *J* will increase *EC*. We implicitly assume that the increase in *EC* for some share of potential drug/drink drivers brings it above a level where it is higher than the expected benefits (*EB*) of the activity that includes driving under the influence of psychoactive substances. We apply an aggregate approach, whereby the increase in enforcement, increasing *Q*, affects the balance between individuals' *EC* and *EB*, leading to some individuals' refraining from driving under

the influence of psychoactive substances; that is, reducing the prevalence and, subsequently (by reducing population attributable risk and fatalities/injuries attributable to drug/drink driving) contributing to a reduced number of fatalities/injuries in road accidents.

We also include the impact from the particular control device used in screening for drugs and medicines. For this purpose we split the subjective risk ($Q$) into two components: the control/enforcement level as such ($\varepsilon$) and the ability/sensitivity of screening devices in detecting driving under the influence of drugs and medicine ($s$):

$$Q(DUI) = \varepsilon \cdot s(DUI) \quad (3)$$

Our quantification of the enforcement level ($\varepsilon$) is based on Elvik (2001), who estimated a 'dose-response' model for measuring the marginal effect of traffic police enforcement based on eight studies (eleven observations). This is an aggregate model that relates enforcement directly to injury accidents. What happens from the dose (enforcement) to the response (injury accidents) is not specified, but can be understood as a result of the deterrence effect, thus effecting via reduced prevalence and subsequent reduction in attributable fatalities/injuries. The dose-response model from Elvik (2001) is shown in Figure 1.

Figure 1

Our estimate of $\varepsilon$, the enforcement level effect on perceived risk of being caught, is read directly from this figure. That is, we can get response effects from enforcement (dose) changes. For example, a (dose of a) doubling of enforcement will yield a "response" of approximately 3.5% reduction, while a tripling will yield approximately 5% reduction. Also small reductions in enforcement levels can be read from the figure: an approximately 10% decrease of enforcement will contribute to an increase in accident levels of approximately 1%, and an approximately 25% decrease will contribute to an

increase in accident levels of approximately 2%. However, contrary to Elvik (2001), we cannot take the response directly to accident levels, but we can apply it to prevalence levels that are more clearly linked to behavioural impact, the deterrence effect. Furthermore, the effect on prevalence is adjusted by *s*, which is the sensitivity of screening devices in detecting driving under the influence of drugs and medicine. In the following, we disregard the effect of (varying) penalty levels (*J*).

Since the dose-response model from Elvik (2001) does not include any specification of screening equipment, for alcohol we adjust the response figure for the possibility that not all drink drivers stopped in enforcement are caught, and that less than 100% sensitivity of the screening device is assumed to affect the deterrence effect (the effect on prevalence from increased enforcement); this is the element *s(DUI)* in Equation (3). Thus, for alcohol, we calculate the response from a particular enforcement (increase) level (*y*%) as:

$$\text{response}^{\varepsilon}_{\text{alcohol}} = y\% \cdot \frac{1}{s_{\text{alcohol}}} \tag{4}$$

If $s_{\text{alcohol}}$=1 (100% sensitivity), then the response can be read directly from the dose-response function in Elvik (2001), e.g. $\text{response}^{\varepsilon}_{\text{alcohol}} = y\% \cdot 1$, equal to 3.5% in the case of a doubling; while if $s_{\text{alcohol}}$<1, the implicit response for perfect screening devices would be higher than predicted in Figure 1.[iii] For drug *α*, using device *X*, the response effect on prevalence is calculated as:

$$\text{response}^{\varepsilon(\text{device}X)}_{\text{drug}\alpha} = y\% \cdot \frac{1}{s_{\text{alcohol}}} \cdot s^{\text{device}X}_{\text{drug}\alpha} \tag{5}$$

We calculate $s^{\text{device}X}_{\text{drug}\alpha}$ from device sensitivity in detecting drug *α* times the share of successful samples; that is, taking into account that for some tested drivers the screening device may not obtain a usable oral fluid collection or provide a usable analysis (Kuijten, 2009).

The estimated sensitivity of the drug screening device, weighted for different drugs with respect to prevalence, enters directly into the estimation of the deterrence effect, i.e. the effect on the prevalence of the drug. We set reference levels of prevalence ($P^R$) that should be obtained from

(random) roadside surveys, and these can be used (with relative risk estimates) to calculate the number of attributable fatalities due to drivers under the influence of the particular drug, using Equation (1):

$$\text{Reference: } PAR^R = \frac{P^R(RR-1)}{(P^R(RR-1))+1} \quad (6)^{iv}$$

The (increased) enforcement level affects the prevalence level, yielding a reduction in prevalence, i.e. a response ("deterrence effect") as depicted in Equations (4) and (5). Thus, we re-calculate the number of attributable fatalities due to driving under the influence of the particular drug, applying the after-enforcement level of prevalence ($P^A$, $P^A \leq P^R$) in Equation (1):

$$\text{After enforcement increase: } PAR_A = \frac{P^A(RR-1)}{(P^A(RR-1))+1} \quad (7)$$

## Device quality and the costs of enforcement

When calculating the cost of (increased) enforcement, the specificity of the screening device and how capable it is at detecting true negatives, have an impact. False positives imply additional costs of reporting and laboratory verification. Taken together, prevalence, sensitivity and specificity predict the proportion of test positives that are genuine, the *positive predictive value*, and the proportion of test negatives that are genuine, the *negative predictive value* (Verstraete, 2005; Verstraete & Labat, 2009; Hoskins, 2005).

Given a positive test for drug *α* using drug screening device *X*, *PPV* will give the probability of a true positive, i.e. the probability that the tested driver really has been driving under the influence of drug *α*. *PPV* increases with sensitivity, specificity and, for given sensitivity and specificity level (below 1), increases with prevalence. 1–*PPV* yields the share of drivers screening false positive in traffic police enforcement using device *X*. Given a negative test for drug *α* using drug screening device *X*, *NPV* gives the probability of a true negative, i.e. the probability that the tested driver has

really not been driving under the influence of drug $\alpha$. *NPV* increases with sensitivity, specificity, but for given sensitivity and specificity level (below 1) it decreases with prevalence. 1–*NPV* yields the share of drivers screening false negative in the traffic police enforcement using device *X*, i.e. the share of offenders that will not be detected (Verstraete, 2005; Verstraete & Labat, 2009; Hoskins, 2005). The prevalence may be higher at the location and hour of traffic police enforcement, due to selective testing, than the overall prevalence found in roadside studies, particularly for enforcing driving under the influence of drugs and medicines (EMCDDA, 2007).

# Material

## The relative risk of injury/fatality of drivers under the influence of psychoactive substances

Various publications present odds ratios (*OR*) for drivers under the influence of psychoactive substances (Chipman *et al.*, 2003; Hels *et al.*, 2011; Krüger & Vollrath, 2004; Mathijssen & Houwing, 2005; Mura *et al.*, 2003; Vaa, 2003). The *OR* estimates have been given for crashes or injuries. Hels *et al.* (2011) present *OR* estimates for both serious injuries and fatalities in road traffic, indicating a higher relative risk of fatality when a driver is under the influence of psychoactive substances, particularly alcohol. Yet, as fatality numbers are much lower than injury numbers, the *OR* estimates for fatalities are more uncertain, and there is an apparent inconsistency in the estimates in as much as the *OR* does not increase monotonically in BAC level. Thus, we combine the input from all references, estimating weighted *OR* averages (Elvik, 2005). We extract implicit standard errors from reported confidence intervals by assuming an underlying normal distribution, thus dividing the upper and lower limits by 1.96 on each side of the mean. In addition to standard weighing by the inverse of the variance, we add two types of subjectively motivated adjustment: The *OR* estimates from Mura *et al.* (2003) fully dominated the unadjusted weighted averages for alcohol, and since they gave *OR* estimates for

injuries (not fatalities), their weights were adjusted by 0.25. Even if we include both the crude and adjusted *OR* estimates from Hels *et al.* (2011), the unadjusted weighted averages are relatively weakly influenced, and the weak influence was particularly the case for the *OR* estimates for fatalities. Even though these estimates are uncertain, they are still prime estimates, as it is *OR* estimates for fatalities that we seek. Thus, we adjusted their weights upward by 50 (and by 100 for the highest BAC level).[v]

To calculate relative risk (*RR*) from *OR* we apply a formula from Zhang and Wu (1998), where we have:

$$RR = \frac{\Pi_1}{\Pi_0}$$

and

$$OR = \frac{\frac{\Pi_1}{1-\Pi_1}}{\frac{\Pi_0}{1-\Pi_0}},$$

where $\Pi_1$ indicates the incidence of the outcome of interest in the exposed group, that is, the probability of fatality when drivers are under the influence of a psychoactive substance; $\Pi_0$ indicates the incidence of the outcome of interest in the non-exposed group, that is, the probability of fatality when drivers are *not* under the influence of a psychoactive substance. Thus, we can calculate *RR* from *OR* as (Zhang & Wu, 1998, p. 1691):

$$RR = \frac{OR}{(1-\Pi_0)+(\Pi_0 \cdot OR)}$$

We set $\Pi_0$ as the annual risk for an average individual road-user (car driver/passenger), combining fatality risk figures per (billion) vehicle km in 2009, from IRTAD (www.irtad.net), with average mileage figures from Eurostat (and IRTAD, for Belgium and the Netherlands). The following values are obtained:

- the Netherlands: $\Pi_0$=0.0000746 (5.6 fatalities per billion km, 13,322 km/yr)

- Belgium: $\Pi_0$=0.0001300 (9.6 fatalities per billion km, 13,537 km/yr)
- Finland: $\Pi_0$=0.0000793 (5.2 fatalities per billion km, 15,257 km/yr)

The resulting relative risk (*RR*) estimates and their 95% lower and upper levels, based primarily on *OR* from Hels *et al.* (2011), are displayed in Table 1.

Table 1

Only for *OR* higher than, say, 100 will the *RR* be substantially different (lower). These are the *RR* values we apply in the calculations of population attributable risk (*PAR*), together with prevalence (*P*) in the three European countries for which CBA is carried out.

## Prevalence of psychoactive substances in European driver populations

The prevalence of alcohol and psychoactive substances in road traffic has been investigated in several studies, but mostly in suspected drivers or victims, and therefore not providing prevalence estimates for the overall driver population (Elliott *et al.*, 2009; Marc & Mura, 2005; Maes *et al.*, 2003; Smink *et al.*, 2001; Christophersen *et al.*, 1999; Ross, 1993). We apply new prevalence estimates based on (random) roadside surveys in several European countries (Houwing *et al.*, 2011). It has to be said that non-response rates were substantially higher in Finland and Belgium than in the Netherlands. Table 2 displays the prevalence estimates.

Table 2

These prevalence (*P*) values enter the calculations of population attributable risk (*PAR*) together with relative risks (*RR*). A common *RR* for alcohol can be estimated by weighing over the prevalence of drivers with different BAC levels; and, likewise, a common *RR* for these six drugs (used separately) can be estimated by weighing over the prevalence of AMP, BZO, COC, MOP, OPI and THC in the driver populations. However, this table presents only single substances. Drug-drug combinations and the combined use of drugs and alcohol have not been included.

## Population attributable risk of psychoactive substances in European countries

The population attributable risk (*PAR*), before enforcement increase (see the reference *PAR* in Equation (8) in Section 2.3), can be estimated from the relative risk (*RR*) estimates in Table 1 and the prevalence (*P*) estimates in Table 2. The resulting *PAR* estimates are displayed in Table 3, and the implicit number of fatalities, as a share of all fatalities, in Table 4.

Table 3

Table 4

Based on these estimates, we get the following picture: Given the estimated *P* and *RR*, driving under the influence of drugs and alcohol is a major cause of road fatalities, particularly in Belgium – alcohol more so than drugs. Our figures are lower than, e.g., the estimates from Assum and Sørensen (2010).

## Current enforcement levels and control/judicial costs

Baseline prevalence levels are influenced by current enforcement levels (control intensity). We could define a "low" drug enforcement level as less than 50 tests per 100,000 inhabitants on a yearly base, a "medium" drug enforcement level as between 50 and 100 and a "high" drug enforcement level as above 100.

Table 5

The Netherlands and Belgium are examples of countries with a current low drug enforcement level. In Finland, the police spend approximately 20,000 hours on drug-testing 8000 tests in traffic; yielding ca. 145 tests per 100,000 inhabitants, i.e. a "high" enforcement level. Table 6 gives the current legal framework for drugs enforcement, the costs and the negative benefits of road-users' time-use.

Table 6

While Belgium and Finland have "zero tolerance" legislation for drugs enforcement, in the Netherlands the tolerance is to a level of impairment (Kuijten, 2009). Cost levels are approximately the same between all three countries.[vi] Drug screening at the roadside is selective, such that there is a higher prevalence level than in the overall driver population. We multiply the average prevalence levels in the driver population (in Table 2) by 10. Also indicated from Table 6 is extra time-use for both Police and road-user in the case of a positive screening result, plus laboratory costs for verifying the result of oral fluid screening.

## Costs of using devices

Monetary figures can be assumed to represent Euro 2009 price levels. The ten devices we consider for our CBA correspond to those assessed by Blencowe *et al.* (2010) and Kuijten (2009), for which there is information about performance in field testing. We do not have exact cost information for all ten devices, so we combined some direct producer information with a few average cost figures from the literature (Hoskins, 2005). We found an average cost of €18 for a sampler. This unit cost will normally decrease substantially when larger quantities of an oral fluid sampler are purchased, such that our cost assumptions are probably at the upper end. For some devices a reader is an integral part of the instrument screening the oral fluid sample, implying an investment in addition to the current costs per oral fluid sampler test. We received reader price information and technical lifetimes for two of three such devices, and the average for the three readers is €12,000, yielding an average investment cost of €3600 for all ten devices. Average reader lifetime is 6.7 years. The number of readers/analysers depends on control level and available control force.[vii] The estimated time-use per screening test includes collection time for oral fluid sample and the time for analysis, with an average equal to 9.58 min (Kuijten, 2009).[viii] It should be said that we omit transport/vehicle costs for the Police (we would expect these to be relatively higher in less densely populated countries like Finland) and we disregard additional negative benefits for the false positives in terms of possible withdrawal of licence and further waiting and inconvenience.

## Sensitivity and specificity of devices

The weighted sensitivity/specificity (and, thus, NPV and PPV) depend on the (relative) prevalence of AMP, BZO, COC, MOP, OPI and THC in the driver populations (Verstraete, 2005; Verstraete & Labat, 2009). Based on the sensitivity/specificity of the assessed devices (Blencowe *et al.*, 2010) and the prevalence figures (Houwing *et al.*, 2011), we obtain the following weighted average sensitivity estimates for the Netherlands, Belgium and Finland: 44.2%, 62.3% and 67.1%, respectively. Weighted average specificity was nearly the same for all three countries, i.e. between 96.8 and 95.8%.

The sensitivity/specificity figures yield fundamental information concerning how the benefit and cost sides in the CBA are affected from each device. Given our modelling of the deterrence effect, higher sensitivity (lower number of false negatives) implies a higher deterrence effect, thus greater reduction in prevalence, and subsequently a greater reduction of fatalities attributable to drug-impaired driving. Furthermore, higher specificity (lower number of false positives) implies lower follow-up laboratory costs (and less negative benefits due to time loss for erroneously detected drivers). Thus, both high sensitivity and high specificity contribute to a higher benefit-cost ratio.

## Uncertainty analysis

We include a comprehensive uncertainty analysis, with simultaneous assessment of various input uncertainty based on simulations. To some extent this is based on subjective assessments of uncertainty/distributions for input components, but the procedure still provides probability distributions of estimates that show relative impact of input uncertainty to the overall uncertainty. Simulation is accomplished using @RISK™ for Excel spreadsheets (Palisade, 2009), which yield ranking coefficients for the input components (prevalence, relative risk, reference control level, device sensitivity, device specificity, unit costs, time-use) in terms of effect on the benefit-cost

ratios. The specific effect of such a ranking coefficient, $b_k$, where $k$ refers to input, can be calculated using the following formula:

$$b_k = \frac{\frac{\text{change in BC ratio}}{sd(\text{BC ratio})}}{\frac{\text{change in input } k}{sd(\text{input } k)}} \quad (8)$$

Division by the standard deviation normalises (standardises) the effects from different inputs. The formula in equation (8) can be rewritten by measuring the change in benefit-cost ratio from a specific input change, i.e. following traditional uncertainty analysis:

$$\text{change in BC ratio} = sd(\text{BC ratio})\frac{b_k \cdot \text{change in input } k}{sd(\text{input } k)} \quad (9)$$

Although we have uncertainty information in some input variables (i.e. confidence intervals), for most inputs we apply truncated normal distributions with fixed truncation limits to avoid "wrong signs" (e.g. negative costs), and set standard deviations as 10, 20 or 30% of the point estimate (Table 7).

Table 7

# Results

We present different levels of drug enforcement increases for the three countries of an average screening device. Since the baseline level of drug enforcement is very different between the

three countries, we include a “very high” increase for the Netherlands (2000%) and a “very low” increase for Finland (10%). These increases yield similar end levels comparable to an enforcement tripling in Belgium (300% increase).

Our CBA/CEA includes a simplified distributional analysis showing components benefiting different stakeholders/sectors. Regarding net benefits for the public sector, we have assumed an average fine level of €2000 per convicted drugged driver (and €200 per convicted drink driver). For the medium enforcement increase level, we include calculations for the combined 10% reduction in alcohol enforcement (“90% alcohol”) due to increase of enforcement of drugs and medicines, implicitly indicating the possibility that additional resources to drug screening are transferred from current budgets allocated to alcohol controls. We include the BC ratio (CBA) and the costs per convicted (CEA). When the BC ratio is negative, that is, when there is a cost reduction that is higher than the benefit reduction (in the “90% alcohol” case), the BC ratio is “not defined”. The basic requirement for efficiency of increased drug enforcement is a benefit-cost (BC) ratio of 1.5 or higher (Bickel *et al.*, 2006).

Table 8a

Table 8b

Table 8c

The indication from Tables 8a, 8b and 8c is that increased drug control is most profitable for the Netherlands and least for Finland. This is logical in terms of baseline enforcement level, since in Finland the drug enforcement level is already considerably higher than in the Netherlands, where an

even larger increase might be cost efficient, since the estimated BC ratio is above 1.5 even for a tenfold increase in enforcement.

Tables 8a, 8b and 8c indicate that the road-users are the stakeholders who will generally benefit most, given a deterrence effect reducing the prevalence of drugs in road traffic and the subsequent improvement in road safety. However, if the public sector decides to decrease alcohol enforcement for the sake of financing increased drug enforcement (for a given budget) the road-user net benefits will decrease (assuming increased drink driving). The total net benefits in the 90% alcohol case (10% reduction of drink-driving control) are higher than in the 100% case, but the difference is minor for Belgium, which can be attributed to currently higher fatality levels due to alcohol in that country and the higher current control level in Finland. The BC ratios are closer between the three countries, comparing 10% increase in Finland, with 300% increase in Belgium and 2000% increase in the Netherlands, but remains lowest for Finland.

The following three figures show the probability densities of the BC ratios for the enforcement tripling (300%) scenario in the Netherlands, Belgium and Finland, based on the uncertainty analysis, with @RISK.

Figure 2a

Figure 2b

Figure 2c

In the case of the Netherlands, more than 95% of the probability density is above 1.5, indicating a fairly safe societal investment, given our assumptions. In the Finnish case, more than 95% of the probability density is below 1.

In the uncertainty analysis, we also assessed which inputs ($k$) to the CBA had the highest ranking coefficients ($b_k$), as given from equation (8). We found a similar pattern in all three countries: increases in judicial costs of convicted drivers have the largest negative ranking coefficient; and increases in the relative risks and prevalences of drugs (with currently high prevalence levels and/or high relative risk) have the highest positive ranking coefficient. In Table 9 we show the effect of changes in input values on the benefit-cost ratios for enforcement tripling in the Netherlands. We consider one small (5%) and one large (50%) "unfortunate" change in input values in terms of effects on the BC ratio (e.g. 5% increase in judicial costs of convicted drivers or 5% decreases in relative risk or prevalence). We selected a few of the inputs that were ranked highest and applied equation (9).

Table 9

The simulated benefit-cost ratio was 4.8 for a 300% enforcement increase in the Netherlands. Thus, not even a 50% increase in judicial costs would bring down the benefit-cost ratio to 1.5 in the case of a tripling in enforcement in the Netherlands.

## Discussion and Conclusions

We have presented a methodology for CBA of law enforcement in relation to drug driving. To our knowledge, our exploratory CBA is an early study assessing the cost efficiency of law enforcement in cases of drug driving. The CBA methodology was applied in three EU countries with varying levels of law enforcement of drug driving offences: Finland, Belgium and the Netherlands. The results of the analysis indicate that increased enforcement is most profitable in the Netherlands and least in Finland. This is logical, since in Finland the baseline enforcement level is considerably higher than in the Netherlands. In Belgium, where the baseline enforcement level is higher than in the Netherlands, a medium increase may be cost efficient, since the estimated BC ratio is above 1.5 for a triple increase. In the Netherlands, even a larger increase may be cost efficient, since the estimated BC ratio is above 1.5 for a tenfold increase of enforcement.

The CBA model enables simplistic calculations of the effect on benefit-cost ratios of simultaneous increases and/or decreases of alcohol and drug enforcements. The additional crash-risk and impairment (fatalities) attributable to drugs (i.e., additional to that caused by alcohol) can be read out of Table 4, which follows from the estimated relative risk and prevalence figures from. Including drug combinations, the drugs and medicines contribute to a doubling of fatalities in Finland compared to drunk driving, while this additional contribution to road fatalities due to drugs is approximately 30% in the Netherlands and about 20% in Belgium. The relative risk figures applied are considerably lower than the recent fatality risk estimates from Hels *et al.* (2011). We used a meta-analytic weighing of several estimates from the literature, but most of these estimates relate to injury risk, not fatality risk. Even if we subjectively gave more weight to the estimates from Hels *et al.*, the resulting numbers of alcohol-related fatalities (that are calculated from relative risk and prevalence

estimates) were lower than those reported by Assum and Sørensen (2010). If the relative risk figures are "too low" they will bias the benefit-cost ratios downwards.[ix]

The CBA model may be considered as too rigid for analysing combined alcohol and drug-use, for at least two reasons: the input variables are generally based on single psychoactive substances, and the model as such handles single substances, not combinations. The effect on benefit-cost ratios of replacing alcohol and drug enforcement programmes one with the other, however, can be read from our results with respect to enforcement reference levels: E.g., in Finland, where the enforcement level for alcohol is "very high", a replacement of some enforcement resources to drugs would probably not affect drunk driving very much.

A main purpose of our paper has been to apply a methodology involving modelling of a deterrence effect, and thereby accident reduction, from enforcement changes (Elvik, 2001; 2011). Our modelling, in particular the figure taken from Elvik (2001), is crucial input to the CBA. We have applied this figure to prevalence levels (instead of accident/fatality numbers, as in its original form) to establish a linkage between the sensitivity of devices and the deterrence effect. The resulting prevalence reduction was linked to fatality reductions via (relative risk estimates) population attributable risk estimates. Since we maintain the relative/percentage effects from Elvik's figure, there is some dependency on the current (absolute) level of enforcement, and contributing to reducing profitability in Finland compared to the other countries when end level of enforcement is similar in the three countries.

An average device based on ten different devices on the market was evaluated. Devices have varying strengths in terms of sensitivity and specificity for different drugs, and differ in terms of unit costs and screening time-use. The specificity of the device and its time consumption for oral fluid sampling and analysis affect the cost side of the CBA. Given a relationship between the objective risk of being caught and the subjective risk perception (Löbmann, 2002), the sensitivity of the screening

device has an influence on the benefit side of the CBA. Although higher sensitivity in detecting drugged driving will increase the safety benefits, the enforcement cost, particularly following a positive test, dominates to such an extent that high specificity is relatively more important than high sensitivity.

The input variables of the on-site oral fluid screening devices are based on the outcomes of both practical evaluation (Kuijten, 2009) and formal testing and analytical evaluation (Blencowe *et al.*, 2010) of the devices. The practical aspects that have been included in the CBA were time consumption and cost of the various devices. However, during the evaluation process, new generations of devices have been developed, presumably with reduced screening time consumption and higher sensitivity for some drugs, and further improvements might be expected in years to come. Moreover, the unit cost of the devices will probably decrease substantially when larger quantities are purchased and applied in regular screening in various countries. These expected developments might yield more favourable BC ratios than the present estimates. Another element is the impact from judicial costs on the BC ratios, identified from the uncertainty analysis; which for example indicates that having only an administrative sanction would yield slightly higher and more robust BC ratios, *ceteris paribus*.

Our estimates remain fully based on the presented assumptions. Our CBA is partial in the sense that some potential effects will always be omitted from a CBA (Moore and Pozdena, 2004). For example, we omit the negative benefits for false positives in terms of possible temporary loss of driving licence, and we also omit possible traffic slowdown costs due to police controls. In addition to simple, limitable changes in input (which were shown not to affect the conclusion for the BC ratio, in the example based on the Dutch data, for triple increase of enforcement), a more fundamental issue concerns the actual/feasible practice of enforcement. For example, will devices/samplers be applied according to our implicit assumptions, that is, does the sensitivity estimate for the devices also represent actual “control efficiency” (Löbmann, 2002)? In any case, it is of course beyond the cost-benefit analysis to consider all such real-life eventualities. This should only be borne in mind

when assessing our numbers. The final conclusion is that increased law enforcement of drug driving based on roadside oral fluid screening is potentially beneficial, particularly in the case of countries that currently have a low enforcement level. However, more CBA of drug driving enforcement is warranted, with particular focus on the modelling of potential drugged drivers' responses to alterations in enforcement from different reference levels.

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[i] This valuation approach is based on the so-called "One Million Euro Test" introduced by the European Commission in 1997, acknowledging that fatality numbers are more readily accessible than injuries and material damage data. "Based on 1990 figures for all member states the total costs per fatality turned out to be one million ECU ... therefore the method is known since as the One Million Euro Test" (Vlakveld *et al.*, 2005, p. 51). Thus, assuming a constant ratio between accidents with fatalities, injuries and material damage, the cost (or valuation) per counted fatality should include the costs of injuries and material damage. Alternatively, we could estimate differentiated effect figures for fatalities and injuries (and material-damage only accidents) and apply differentiated valuations.

[ii] If this were the case, that only control quantity and not control quality impacted on deterrence and benefits, then the CBA related to device choice would be clear: select the device with lowest sensitivity, because this would reduce the additional costs of following-up screened positives in laboratories.

[iii] Screening devices have been improved over the years for alcohol screening too; however, in our calculations we disregard the possibility of considerable change from the time of the eight studies applied by Elvik (2001) up to today. We also disregard differences between alcohol screening devices in terms of sensitivity. The ability to detect driving under the influence of psychoactive substances also depends on the concentration of the substance, either the BAC level for alcohol or the medicine/drug in saliva (Blencowe *et al.*, 2010; Verstraete & Labat, 2009; Verstraete & Raes, 2006; Maes *et al.*, 2003). In addition to the result of the oral fluid screening device, the police officer will base his/her conclusion that a driver is suspected of having psychoactive substances on observing the behaviour and reaction of the driver. Furthermore, oral fluid screening devices can't detect all types of drug classes (Kuijten, 2009).

[iv] The *PAR* for combined risks is given as: Combined $PAR = 1 - (1–PAR_1)(1–PAR_2)(1–PAR_3)...$ . This formula is applied when deducing the sums of fatalities due to driving under the influence of drugs or alcohol.

[v] The relative weight of the *OR* estimates from Hels *et al.* (2011) will then increase from between 4% (for cocaine and BAC≥1.2) and 92% (for medical opioids) to an interval between 4% (for cocaine) and 99.7% (for medical opioids); the relative weight of the *OR* estimate for fatality when driving with BAC≥1.2 increases to nearly 17%. The relative weight of the *OR* estimates from Mura *et al.* (2003) is reduced from an interval of 18-94% (for BAC between 0.5 and 0.8, BAC between 0.8 and 1.2, and BAC≥1.2) to an interval of 6-34%.

[vi] Regarding time cost for road users, we applied the following time valuations for Finland: ((€10.04+€8.13·0.75)·80%)+€17.4·20%, where €10.04 is the car driver's valuation, €8.13 the car passengers' valuation and €17.4 the valuation per heavy vehicle. These are Finnish Road Administration figures. We applied Shires and de Jong (2009) for calculating relative value differences for the Netherlands and Belgium, but for all three countries the weighted value is close to €16. Shires and de Jong (2009) present the following (valuations and shares) for the Netherlands: commuting (€9.94·0.48), business (€27.84·0.03), leisure (€7.96·0.43) and heavy vehicle transport (€40·0.06); for Belgium: commuting (€9.82·0.48), business (€27.59·0.03), leisure (€7.88·0.43) and heavy vehicle transport (€40·0.06); and for Finland: commuting (€10.3·0.48), business (€28.54·0.03), leisure (€8.18·0.43) and heavy vehicle transport (€40·0.06). Maerivoet and De Moor (2006), basing their values on Nellthorp *et al.* (2001), applied commuting (€6·0.48), business (€21·0.03), leisure (€4·0.43) and heavy vehicle transport (€40·0.06).

[vii] The number of readers needed for a tenfold enforcement increase was set to 40 for the Netherlands, 114 for Belgium and 288 for Finland for two of three devices with reader (but only to half of these numbers for the third device, which had a larger reader with higher capacity). For lower enforcement increases, e.g. for a 300% increase, the number of reader/analyser investments will be 0.3 of the number for a tenfold increase, in our CBA, etc.

[viii] For an assessment of the analytical reliability of these devices, see Blencowe *et al.* (2010, Annex 9).

[ix] We also tried a CBA only using the RR estimates from Hels *et al.* (2011), that yielded somewhat higher BC ratios, but the implications for the three countries remained more or less the same.

# Tables

***Table 1. Estimated relative risk (RR) of fatality from driving under the influence of psychoactive substances***

| | Netherlands | Belgium | Finland |
|---|---|---|---|
| alcohol - 0.2-0.5 BAC | **3.76** | **3.76** | **3.76** |
| alcohol - 0.5-0.8 BAC | **5.87** | **5.87** | **5.87** |
| alcohol - 0.8-1.3 BAC | **21.51** | **21.49** | **21.51** |
| alcohol - >= 1.3 BAC | **33.54** | **33.48** | **33.54** |
| amphetamines (AMP) | **9.87** | **9.87** | **9.87** |
| benzodiazepine (BZO) | **4.67** | **4.67** | **4.67** |
| cocaine (COC) | **1.89** | **1.89** | **1.89** |
| medical opioides (MOP) | **4.87** | **4.87** | **4.87** |
| opiates (OPI) | **3.53** | **3.53** | **3.53** |
| cannabis (THC) | **1.55** | **1.55** | **1.55** |

***Table 2. Prevalence (P) of psychoactive substances (reference level / before enforcement increase)***

| | Netherlands | Belgium | Finland |
|---|---|---|---|

| | | | |
|---|---|---|---|
| alcohol - 0.2-0.5 BAC | 1.23% | 3.67% | 0.34% |
| alcohol - 0.5-0.8 BAC | 0.55% | 1.65% | 0.17% |
| alcohol - 0.8-1.3 BAC | 0.25% | 0.73% | 0.09% |
| alcohol - >= 1.3 BAC | 0.12% | 0.37% | 0.04% |
| amphetamine (AMP) | 0.19% | 0.12% | 0.05% |
| benzodiazepine (BZO) | 0.40% | 2.01% | 0.79% |
| cocaine (COC) | 0.30% | 0.20% | 0.03% |
| medical opioides (MOP) | 0.16% | 0.75% | 0.56% |
| opiates (OPI) | 0.01% | 0.09% | 0.00% |
| cannabis (THC) | 1.67% | 0.35% | 0.04% |

***Table 3. Estimated population attributable risk (PAR) due to driving under the influence of psychoactive substances***

| | Netherlands | Belgium | Finland |
|---|---|---|---|
| alcohol - 0.2-0.5 BAC | 3.28% | 9.18% | 0.93% |
| alcohol - 0.5-0.8 BAC | 2.62% | 7.44% | 0.82% |
| alcohol - 0.8-1.3 BAC | 4.80% | 13.07% | 1.72% |
| alcohol - >= 1.3 BAC | 3.84% | 10.65% | 1.37% |
| amphetamine (AMP) | 1.66% | 1.05% | 0.44% |
| benzodiazepine (BZO) | 1.45% | 6.87% | 2.82% |

| | | | |
|---|---|---|---|
| cocaine (COC) | 0.27% | 0.18% | 0.03% |
| medical opioides (MOP) | 0.62% | 2.82% | 2.12% |
| opiates (OPI) | 0.03% | 0.23% | 0.00% |
| cannabis (THC) | 0.91% | 0.19% | 0.02% |

***Table 4. Estimated fatality numbers due to driving under the influence of psychoactive substances***

| | Netherlands | Belgium | Finland |
|---|---|---|---|
| alcohol - 0.2-0.5 BAC | 24.6 | 86.7 | 3.21 |
| alcohol - 0.5-0.8 BAC | 19.7 | 70.3 | 2.84 |
| alcohol - 0.8-1.3 BAC | 36.0 | 123.4 | 5.9 |
| alcohol - >= 1.3 BAC | 28.8 | 100.5 | 4.7 |
| SUM fatalities – DUI of alcohol | 103.4 | 327.6 | 16.4 |
| amphetamine (AMP) | 12.4 | 9.9 | 1.52 |
| benzodiazepine (BZO) | 10.9 | 64.9 | 9.7 |
| cocaine (COC) | 1.99 | 1.67 | 0.09 |
| medical opioides (MOP) | 4.61 | 26.6 | 7.29 |
| opiates (OPI) | 0.19 | 2.1 | 0.00 |
| cannabis (THC) | 6.86 | 1.82 | 0.08 |
| SUM fatalities – DUI of drugs* | 36.3 | 103.7 | 18.4 |
| SUM fatalities – DUI of drugs and alcohol* | 134.6 | 395.4 | 33.9 |

| | | | |
|---|---|---|---|
| SUM road fatalities (annually: 2008) | 750 | 944 | 344 |
| Share fatalities – DUI of alcohol | 13.78% | 34.71% | 4.76% |
| Share fatalities – DUI of drugs | 4.84% | 10.99% | 5.35% |
| Share fatalities – DUI of drugs and alcohol | 17.95% | 41.88% | 9.85% |

* Includes drug mix (Houwing *et al.* 2011, Hels *et al.* 2011).

***Table 5. Current enforcement levels (reference level / before enforcement increase)***

| Current enforcement level | Netherlands | Belgium | Finland |
|---|---|---|---|
| Number of alcohol tests | 1,500,000 | 750,000 | 2,300,000 |
| Level of alcohol enforcement (hours) | 250,000 | 42,000 | 230,000 |
| Level of alcohol enforcement (per 100,000 inhabitants) | 7,273 | 1,905 | 36,364 |
| Level of alcohol enforcement (hours per 100,000 vehicle km) | 0.2273 | 0.0442 | 0.4600 |
| Enforcement level – alcohol | High | High | High |
| Number of drug tests. | 1,000 | 3,785 | 8,000 |
| Level of drug enforcement (hours) | 6,500 | 26,000 | 20,000 |
| Level of drug enforcement (per 100,000 inhabitants) | 6 | 36 | 145 |
| Level of drug enforcement (hours per 100,000 vehicle km) | 0.0059 | 0.0274 | 0.0400 |
| Enforcement level – drugs | Low | Low | High |

***Table 6. Current enforcement system (legal frames) for drugs control, and control/judicial costs***

| Current enforcement level | Netherlands | Belgium | Finland |
|---|---|---|---|
| Enforcement system | Impairment | Zero tolerance | Zero tolerance |
| Campaign investment costs (€) | 1,000,000 | 636,364 | 333,333 |
| Police costs per hour (€) | 80 | 80 | 60 |
| Laboratory costs per positive (€) | 325 | 359 | 300 |
| Judicial costs per convict (€) | 3,000 | 3,000 | 3,000 |
| Police – additional time per positive (min) | 90 | 90 | 90 |
| Road user – additional time per positive (min) | 60 | 60 | 60 |
| Road user negative benefits per hour (€) | 16 | 16 | 16 |

***Table 7. Assumed uncertainty in input variables, truncation limits, standard deviations, and expected means, per country, for average screening device***

| | St.dev. in % of mean | Trunc-ation low | Trunc-ation high | Netherlands | | Belgium | | Finland | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | simulated estimate | simulated st.dev. | simulated estimate | simulated st.dev. | simulated estimate | simulated st.dev. |
| Sensitivity | 10% | 0% | 100% | 44.4% | 10.6% | 62.4% | 10.4% | 67.1% | 10.3% |
| Specificity | 10% | 0% | 100% | 90.7% | 6.6% | 90.4% | 6.7% | 90.2% | 6.8% |
| Successful collections | 10% | 0% | 100% | 89.1% | 7.0% | 89.1% | 7.0% | 89.1% | 7.0% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Successful analyses | 10% | 0% | 100% | 80.6% | 8.2% | 80.6% | 8.2% | 80.6% | 8.2% |
| Prevented fatality (€) | 100000 | 100 K | 30 M | 7,999,968 | 1,599,859 | 7,999,963 | 1,599,993 | 7,000,002 | 1,399,867 |
| Power of sensitivity (default=1) | 10% | 0 | 2 | 1.0 | 0.1 | 1.0 | 0.1 | 1.0 | 0.1 |
| Cost of devices with reader (€) | 20% | 50 | 50 K | 3,600 | 719 | 3,600 | 719 | 3,600 | 719 |
| Cost of sampler (€) | 20% | 1 | 50 | 16.50 | 3.30 | 16.50 | 3.30 | 16.50 | 3.30 |
| Lifetime of devices with reader (ys) | 20% | 1 | 30 | 4.3 | 0.9 | 4.3 | 0.9 | 4.3 | 0.9 |
| Screening time (min) | 20% | 0.5 | 30 | 9.6 | 1.9 | 9.6 | 1.9 | 9.6 | 1.9 |
| Police labour costs (€) | 30% | 10 | 200 | 80.1 | 23.8 | 80.1 | 23.8 | 60.2 | 17.8 |
| Police extra time pos. test (h) | 30% | 0,5 | 12 | 5.0 | 1.5 | 5.0 | 1.5 | 5.0 | 1.5 |
| Laboratory cost (€) | 30% | 30 | 700 | 325 | 97 | 359 | 107 | 300 | 89 |
| User time (min) | 30% | 1 | 50 | 16.0 | 4.8 | 15.9 | 4.7 | 16.4 | 4.9 |
| User extra time pos. test (h) | 30% | 0.5 | 10 | 3.0 | 0.9 | 3.0 | 0.9 | 3.0 | 0.9 |
| Judicial cost (€) | 30% | 100 | 10K | 3,002 | 897 | 3,002 | 897 | 3,002 | 897 |
| Info campaign cost (€) | 30% | 10K | 20M | 1,000,053 | 298,381 | 636,709 | 190,326 | 333,544 | 99,647 |
| *RR* | | | | | | | | | |
| AMP | 30% | 0.5 | 10K | 9.88 | 2.95 | 9.88 | 2.95 | 9.88 | 2.95 |
| BZO | 30% | 0.5 | 10K | 4.68 | 1.39 | 4.68 | 1.39 | 4.68 | 1.39 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| COC | 30% | 0.5 | 10K | 1.90 | 0.55 | 1.90 | 0.55 | 1.90 | 0.55 |
| MOP | 30% | 0.5 | 10K | 4.88 | 1.45 | 4.88 | 1.45 | 4.88 | 1.45 |
| OPI | 30% | 0.5 | 10K | 3.54 | 1.05 | 3.54 | 1.05 | 3.54 | 1.05 |
| THC | 30% | 0.5 | 10K | 1.57 | 0.45 | 1.57 | 0.45 | 1.57 | 0.45 |
| *P* | | | | | | | | | |
| AMP | 30% | $1E^{-6}$ | 0.2 | 0.190% | 0.057% | 0.120% | 0.036% | 0.050% | 0.015% |
| BZO | 30% | $1E^{-6}$ | 0.2 | 0.400% | 0.120% | 2.011% | 0.601% | 0.790% | 0.236% |
| COC | 30% | $1E^{-6}$ | 0.2 | 0.300% | 0.090% | 0.200% | 0.060% | 0.030% | 0.009% |
| MOP | 30% | $1E^{-6}$ | 0.2 | 0.160% | 0.048% | 0.750% | 0.224% | 0.560% | 0.168% |
| OPI | 30% | $1E^{-6}$ | 0.2 | 0.010% | 0.003% | 0.090% | 0.027% | 0.00012% | 0.00002% |
| THC | 30% | $1E^{-6}$ | 0.2 | 1.671% | 0.500% | 0.350% | 0.105% | 0.040% | 0.012% |
| *P*-SELECTIVE | | | | | | | | | |
| Drugs | 30% | 1 | 20 | 10.0 | 2.0 | 10.0 | 2.0 | 10.0 | 2.0 |

* K=1000 and M=1,000,000. The prevented fatality valuation is based on the so-called "1 Million Euro test", also including the costs of injuries and material damages "per counted fatality", thus assuming a constant ratio between accident with fatalities, injuries and material damage. The average device reader cost, for the three devices including reader, would be approximately 12,000 EUR. For nine of ten devices, the sampler cost is set to 18 EUR.

***Table 8a. Drug enforcement increases (average device), with simplistic distributive analysis – the Netherlands***

| | Medium enforcement increase (tripling) | | High enforcement increase (tenfold) | Very high enforcement increase (twentyfold) |
|---|---|---|---|---|
| | 90% alcohol | 100% alcohol | | |
| Control density – drugs | 0.018% | | 0.061% | **0.121%** |

| | | | | |
|---|---|---|---|---|
| Control density – alcohol | 8.2% | 10.0% | 10.0% | 10.0% |
| Road user net benefits | -328,130 | 3,676,351 | 5,854,996 | 5,854,996 |
| Public sector net benefits | 14,128,056 | 1,021,496 | 170,424 | 170,424 |
| Costs per convicted (CEA) | | 4,307 | 4,165 | 4,143 |
| Costs per prevented fatality (CEA) | | 1,578,533 | 4,291,437 | 8,010,759 |
| Benefit-cost ratio (CBA) | 0.03 | 5.06 | 1.86 | 0.99 |
| Net benefits (CBA) | 13,323,341 | 4,221,262 | 3,880,787 | -69,040 |

***Table 8b. Drug enforcement increases (average device), with simplistic distributive analysis – Belgium***

| | Low enforcement increase (50%) | Medium enforcement increase (tripling) | | High enforcement increase (tenfold) |
|---|---|---|---|---|
| | | 90% alcohol | 100% alcohol | |
| Control density – drugs | 0.054% | **0.108%** | | 0.360% |
| Control density – alcohol | 7.9% | 6.4% | 7.9% | 7.9% |
| Road user net benefits | 5,578,090 | 2,924,660 | 13,949,573 | 22,243,160 |
| Public sector net benefits | 1,535,291 | 16,833,429 | 2,657,025 | -5,296,000 |
| Costs per convicted (CEA) | 4,065 | | 4,005 | 3,989 |
| Costs per prevented fatality (CEA) | 1,692,002 | | 2,663,730 | 7,452,807 |
| Benefit-cost ratio (CBA) | 4.72 | not def. | 3.00 | 1.07 |
| Net benefits (CBA) | 6,288,184 | 16,457,302 | 13,305,811 | 2,093,617 |

***Table 8c. Drug enforcement increases (average device), with simplistic distributive analysis – Finland***

| CBA component | Very low enforcement increase (10%) | Low enforcement increase (50%) | Medium enforcement increase (tripling) | |
|---|---|---|---|---|
| | | | 90% alcohol | 100% alcohol |
| Control density – drugs | **0.160%** | 0.218% | 0.436% | |
| Control density – alcohol | 46% | 46% | 38% | 46% |
| Road user net benefits | 189,636 | 948,519 | 2,037,611 | 2,332,186 |
| Public sector net benefits | -112,876 | -446,049 | 6,934,795 | -2,321,119 |
| Costs per convicted (CEA) | 4,476 | 4,177 | | 4,120 |
| Costs per prevented fatality (CEA) | 8,877,858 | 8,281,212 | | 13,061,375 |
| Benefit-cost ratio (CBA) | 0.78 | 0.84 | not def. | 0.53 |
| Net benefits (CBA) | -77,948 | -271,072 | 5,878,243 | -3,083,096 |

***Table 9. Sensitivity analysis – simulated BC ratio; @RISK calculations entered into equation (9), sub-section 2.5, for 5 and 50% "unfortunate" changes in input values; tripling of enforcement, the Netherlands.***

| **Input (*k*)** | **Change in input (%)** | **Change in Input** | **SD of input** | **SD of BC ratio** | **Ranking coefficient** | **Change in BC ratio** |
|---|---|---|---|---|---|---|
| Judicial costs per convict (€) | 5 | 150€ | 896 | 1.82 | -0.57 | -0.17 |
| | 50 | 1500€ | 896 | 1.82 | -0.57 | -1.74 |
| RR THC | -5 | -0.0776 | 0.45 | 1.82 | 0.37 | -0.12 |
| | -50 | -0.7763 | 0.45 | 1.82 | 0.37 | -1.17 |
| RR AMP | -5 | -0.4937 | 2.95 | 1.82 | 0.28 | -0.09 |
| | -50 | -4.9367 | 2.95 | 1.82 | 0.28 | -0.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| RR BZO | 5 | -0.2337 | 1.392 | 1.82 | 0.27 | -0.08 |
| | 50 | -2.3366 | 1.392 | 1.82 | 0.27 | -0.83 |
| P AMP | -5 | -0.0001 | 0.00057 | 1.82 | 0.25 | -0.08 |
| | -50 | -0.0010 | 0.00057 | 1.82 | 0.25 | -0.76 |

* The simulated BC ratio was equal to 4.8, for tripling of enforcement of drug-impaired driving in the Netherlands.