WORKING FOR A HEALTHY FUTURE

IOM Research Project: P937/19
May 2011

Health, socio-economic and environmental aspects of possible amendments to the EU Directive on the protection of workers from the risks related to exposure to carcinogens and mutagens at work

o-Toluidine

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SUMMARY

3,3'-Dimethylbenzidine or ortho-toluidine (o-toluidine) may cause bladder cancer. Exposure to o-toluidine has been classified as a group 2b carcinogen (Possibly carcinogenic to humans) by the International Agency for Research on Cancer (IARC) and as Cat 2 carcinogens in the EU under the classification and labelling legislation and it is therefore within the scope of the EU Carcinogens Directive. However, there is no occupational exposure limit (OEL) for o-toluidine specified in the Directive.

This report considers the likely health, socioeconomic and environmental impacts associated with possible changes to the Carcinogens Directive, in particular the possible introduction of a limit value of either 0.1 ppm or 1 ppm, with an associated skin notation to reflect the potential uptake of o-toluidine through the skin.

Ortho-toluidine is a synthetic aromatic amine, which is used primarily as feedstock in chemical synthesis. As recently as 2000 the major use of o-toluidine was in the production of dyes and pigments, although in Europe this use is decreased because of regulatory restrictions. It is estimated that approximately 5,500 workers in the EU are potentially exposed to o-toluidine, of which about 2,900 are in manufacture of chemicals, chemical products and man-made fibres (NACE 24) or manufacture of rubber products (NACE 251). It was judged that 98% of exposures in these groups were less than 0.1 ppm, which corresponds to a geometric mean concentration of 0.01 ppm (assumed geometric standard deviation of 3). In recent years exposure levels have been decreasing by about 8.8% per annum.

We estimate that in 2010 in the EU there will be about 7 deaths from bladder cancer (22 incident cases) that might be attributable to past exposure to o-toluidine, which corresponds to about 0.017% of all bladder cancer deaths and a loss of 120 Disability-Adjusted Life Years (DALYs). In the absence of any intervention the health burden is predicted to drop steadily over the next 50 years. In 2060 it is predicted that there will be no deaths and possibly one bladder cancer registration that could be attributed to o-toluidine exposure at work (4 DALYs).

The main costs associated with inaction occur in the period 2010-2040, and these are predominately the result of past exposure. It is estimated that in total over the next 60 years there will be between €86m and €696m of health costs if no limit value is introduced, with the highest costs falling on Germany, France, Italy and the UK.

It is judged that compliance with an OEL of 1 ppm could be achieved with no cost implications and that introducing a limit of 0.1 ppm would incur limited costs (between €0.03m and €0.09m). However, neither limit is predicted to give rise to any important reduction in bladder cancer deaths or registrations over the baseline assumptions, primarily because exposures are already very low. There are no monetised health benefits from introducing a limit at 1 ppm and between €1m and €7.6m for the 0.1 ppm limit.

It are not expected that there will be any important social, macro-economic or environmental impacts.

1 PROBLEM DEFINITION

1.1 OUTLINE OF THE INVESTIGATION

3,3'-Dimethylbenzidine or ortho-toluidine (o-toluidine) may cause bladder cancer. Exposure to o-toluidine has been classified as a group 2b carcinogen (Possibly carcinogenic to humans) by the International Agency for Research on Cancer (IARC)[1] and as Cat 2 carcinogens in the EU under the classification and labelling legislation[2]. o-toluidine is therefore already regulated as a carcinogen throughout the EU. In this assessment we consider the impacts of introducing an exposure limit for o-toluidine within the EU Carcinogens and Mutagens Directive.

The key objectives of the present study are to identify the technical feasibility and the socioeconomic, health and environmental impacts of introducing a regulatory exposure limit for o-toluidine of 0.1 ppm or 1 ppm.

1.2 OELS/EXPOSURE CONTROL

Existing national OELs (occupational exposure limits) in EU member states are presented in Table 1.1. These are expressed as long-term limits, averaged over an 8-hour working day or short-term exposure limits (STELs), i.e. 15 minutes. OELs from selected countries outside the EU are also presented for comparison.

Table 1.1 Occupational exposure limits in various EU member states and selected countries outside the EU

Country	OEL - long term (ppm)	OEL - STEL (ppm)
Austria	0.1	0.4
Belgium	2	-
Denmark	2	4
France	2	-
Hungary	-	0.1
Spain	0.2	-
Netherlands	-	-
Poland	0.67	2
United Kingdom	0.2	-
Canada - Quebec	2	-
Switzerland	0.1	-
USA - OSHA	5	-

Source: http:www.dguv.de/bgia/en/gestis/limit_values/index.jsp

The long term OEL from the EU member states range from 0.1 to 2 ppm (0.4 to 8.8 mg/m^3). Austria, Denmark, Hungary and Poland have STELs ranging from 0.1 to 4 ppm (0.5 to 20 mg/m^3). For the purposes of this report OELs of 0.1 and 1 ppm (equivalent to 0.4 or 4.4 mg/m^3) are considered typical for the EU. In most jurisdictions o-toluidine has been assigned a skin notation.

[1] Available at: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf
[2] Available at: http://ecb.jrc.ec.europa.eu/esis/

1.3 DESCRIPTION OF DIFFERENT USES

Ortho-toluidine is a synthetic aromatic amine, which is used primarily as feedstock in chemical synthesis. At standard temperature and pressure it is a colourless to light yellow liquid. Currently the major use of o-toluidine is in the production of methyl ethyl aniline which is used as an intermediate in the production of herbicides including metolachlor and acetochlor. As recently as 2000 the major use of o-toluidine was in the production of dyes and pigments, and o-toluidine continues to be used for this purpose (IARC, 2010; IARC, 2000). However, EU directive 2002/61/EC restricted the marketing and use of Azodyes. These dyes can release aromatic amines (including o-toluidine) in detectable concentrations from finished products. The implementation of this directive has likely contributed to the decline in the use of o-toluidine in dyes and pigments. o-toluidine is also used in the synthesis of rubber chemicals such as the rubber antioxidant di-tolyl-phenyl-p-phenylenediamine (DTPD) and the activator for rubber accelerators, di-o-tolyl-guanidine (DOTG); in the production of epoxy resin hardeners such as methylene-bis-2-methylcyclohexylamine; in the synthesis of fungicide intermediates and in the production of pharmaceutical intermediates. Minor uses of o-toluidine as an intermediate in organic synthesis and as an ingredient in a clinical laboratory reagent for the analysis of glucose in blood have also been reported.[3] In the rubber industry o-toluidine can be released as a thermal decomposition product of DOTG during vulcanization and immediately after post-curing of rubber products (Korinth *et al* 2007).

Production of o-toluidine begins with the mononitration of toluene by a mix of nitric acid and sulphuric acid. This produces the *ortho, meta* and *para* isomers of nitro toluene in the respective ratios of 15:1:19. The isomers are then separated by distillation and reduced to toluidines by vapour-phase hydrogenation using metal catalysts such as Raney nickel, copper, molybdenum, tungsten, vanadium, and noble metals.

Tobacco smoke contains o-toluidine and exposure to environmental tobacco smoke may occur in many industries. However, the levels of exposure to o-toluidine from environmental tobacco smoke are likely to be very low. Palmiotto *et al* (2001) measured the concentration of nine primary aromatic amines, including o-toluidine, in indoor and outdoor air in Italy. The measured summed concentration of the nine aromatic amines ranged from 3 ng/m^3 in a hospital ward to 207 ng/m^3 in a discotheque. The maximum measured concentration of all nine aromatic amines (207 ng/m^3) was three orders of magnitude lower than the lower of the two typical EU OELS (0.4 mg/m^3) so the contribution of environmental tobacco smoke to occupational exposure to o-toluidine is expected to be minimal and will not be considered in this report.

1.4 RISKS TO HUMAN HEALTH

1.4.1 Introduction

Bladder cancer is a relatively common cancer that is generally diagnosed on people over 60 years of age. There are about twice as many cases diagnosed on men compared to women. In the EU it comprises about 5% of all cancer incidence (Ferlay *et*

[3] *o-toluidine* and *o-toluidine* Hydrochloride. Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program. 2005

al, 2007). Key environmental risk factors are cigarette smoking, some industrial chemicals, diet and genetic factors. Mortality amongst European men, especially younger men, has been dropping steadily since the mid-1970s, which is probably due to changes in smoking prevalence and reductions in occupational exposure to aromatic amines such as benzidine and α-and ß-naphthylamine (Levi *et al*, 2004).

Early symptoms of bladder cancer include intermittent haematuria (blood in the urine), changes in the frequency of urination and pain when urinating, although all of these symptoms are also associated with other non-malignant conditions. About three quarters of people diagnosed with bladder cancer can be treated by relatively minor surgery (transurethral resection of superficial bladder cancer), with chemotherapy and/or immunotherapy, giving a relatively good prognosis. For more serious cases of bladder cancer (muscle invasive tumours) the treatment options include surgery, chemotherapy and radiotherapy. Survival rates are lower for these types of tumours.

1.4.2 Summary of the available epidemiological literature on risk

IARC have recently reviewed the evidence for the carcinogenicity of o-toluidine (IARC, 2010) including all the epidemiological evidence available. Early studies identified excesses of bladder cancer in workers in the manufacture dye-stuffs; exposure to o-toluidine was experienced together with exposures to other aromatic amines such as aniline, benzidine, 1- and 2-naphthylamine, auramine and magenta (Case and Pearson, 1954; Case *et al* 1954; Rubino *et al*, 1982). No deaths from bladder cancer were found in workers in aromatic amine-based dye production areas from 1914 to 1958 at a chemical plant in the United States (Ott and Langer 1983) nor in male workers employed for at least twelve months in the period 1929–1982 in the production and processing of 4-chloro-*ortho-toluidine* at a dyestuffs manufacturing plant in Frankfurt, Hessen, Germany (Stasik, 1988). Two incident cases of urothelial carcinoma were subsequently identified in this workforce.

A marked excess of bladder cancer cases based on eight cases was reported (SIR 72.7; 95% CI, 31.4–143.3) in workers employed in the 4-chloro-*ortho-toluidine* production plant in the German study before improvements in industrial hygiene were made in 1970. No quantitative measure of exposure to 4-chloro-*ortho*-toluidine was available, and exposure to other amines was also present. Three of the eight cases were non-smokers, one was a former smoker, two were smokers and the smoking habits of the remaining two were unknown. Consequently, some bias in the estimate of excess risk may be present. The excess of bladder cancer could not be attributed with any certainty to *ortho*-toluidine or to any one of the other compounds present.

There have been a series of papers reporting results for bladder cancer in a cohort of workers exposed to o-toluidine and aniline at a US chemical plant. Overall, 13 cases of bladder cancer were observed for the period 1973–1988 (SIR 3.6; 95% CI, 1.9–6.2), seven of which occurred in the definitely exposed group (SIR 6.5; 95% CI, 2.6–13.3), four in the possibly exposed group (SIR 3.7; 95% CI, 1.0–9.4) and the remaining two cases in non-exposed workers (SIR 1.4; 95% CI 0.2–5.0) (Ward *et al* 1991). Bladder cancer incidence was particularly elevated in employees who had worked in the exposed department for more than 10 years; six of the seven exposed cases occurred in this sub-cohort (SIR 27.2; 95% CI, 10.0–59.2). Data on smoking were available for only 143 study subjects but suggested that confounding from smoking could explain no more than a small fraction of the observed bladder cancer excess. Other chemical exposures at the plant included aniline which is not known to induce bladder cancer in humans or animals and 4-Aminobiphenyl, identified as a potential low-level contaminant in some bulk samples of process chemicals at the plant in 1990 (Ward & Dankovic, 1991), which is potent human bladder carcinogen.

A subsequent mortality analysis of the same cohort for the period 1946–1994 (Prince *et al*, 2000) found only two deaths from bladder cancer in the total cohort (SMR 2.1; 95% CI, 0.2–7.4). One of these deaths occurred in the definitely exposed group (SMR 3.8; 95% CI, 0.1–21.1). A further 19 cases of bladder cancer occurring in this cohort, 18 of which were diagnosed in the later period of 1989–2003, have been identified (Markowitz & Levin, 2004; Markowitz, 2005). Ten of these cases were stated to be members of the definitely exposed subgroup.

In a reanalysis of the original study, exposure information was updated increasing the numbers of workers in the definitely and possibly exposed categories; cancer incidence data was available until the end of 1988 and mortality data to the end of 1994 (Carreon *et al*, 2010). Two bladder cancer deaths were observed, one among those definitely exposed and one among those probably not exposed (SMR=1.98, 95% CI 0.05, 11.05 and SMR 3.0, 95% CI 0.08, 16.71, respectively). Thirteen cases of bladder cancer were observed versus 3.57 expected (SIR=3.64, 95% CI 1.94, 6.23). Among workers classified as definitely exposed, increasing risks were observed as duration of employment increased: < 5years SIR=1.25 (95%CI 0.03, 6.97), 5-10 years SIR =3.67 (95%CI 0.09, 20.44), >10 years SIR=11.09 (95%CI 5.07, 21.05); standardised rate ratios < 5 years SRR=1, 5-10 years SRR=2.00 (95%0.13, 32.05), >10 years SRR=6.07 (95% CI 0.77 to 48.17). A similar relationship was shown by time since first employment in the exposed departments e.g. for >20 years, SRR= 3.39 (95% CI 0.40, 29.03).

Sorahan has also published several papers relating to a study of workers exposed to several aromatic amines in a factory manufacturing chemicals for the rubber industry in the United Kingdom (Sorahan & Pope, 1993; Sorahan *et al,* 2000; Sorahan, 2008). All subjects had at least six months' employment in the factory and some employment in the period 1955–1984. Mortality was examined for the period 1955–1996 and cancer incidence for the period 1971–1992. The study reported in 2000 included 2160 male production workers, 605 of whom had been exposed to one or more of the four chemicals under investigation (aniline, 2-mercaptobenzothiazole, phenyl-β-naphthylamine, ortho-toluidine) including 53 workers who were exposed to o-toluidine. In the latter sub-cohort, three bladder cancer deaths were observed (SMR 15.9; 95% CI, 3.3–46.4). A total of 30 bladder cancers were identified in the overall cohort on the basis of death certificate or cancer registration data. Internal analysis (Poisson regression) revealed a significant association between the risk of bladder cancer and duration of exposure to o-toluidine (1–4 years, n = 2, RR 6.7; 95% CI, 1.6–28.4; 3-5 years, n = 1, RR 7.7; 95% CI, 1.0–56.9). In the most recent update (Sorahan, 2008) in the sub-cohort exposed to o-toluidine the SMR for bladder cancer was 11.16 (95%CI 2.30, 32.6) and the SIR for bladder cancer was 5.56 (95%CI 1.51, 14.22). There were also increasing risks for both mortality and cancer incidence by duration of exposure: mortality <5 years SRR=4.68 (95%CI 1.66, 13.2), >5 years SRR=6.99 (95%CI 1.66, 28.9); cancer incidence (adjusted simultaneously for exposure to 3 other carcinogens including aniline) <5 years SRR=3.72 (95%CI 1.21, 11.4), >5 years SRR=3.38 (95%CI 0.67, 17.0). These results are similar to those found in the US study (Carreon, 2010).

1.4.3 Choice of risk estimates to assess health impact

The study by Sorahan of UK workers exposed to o-toluidine in rubber manufacturing found a SIR=5.56 (95%CI 1.51, 14.22) for bladder cancer. In a US study of chemical manufacture workers the SIR for bladder cancer for those workers definitely exposed to o-toluidine was 5.84 (95%CI 2.91, 10.45). As Sorahan's estimate does not adjust for other potential bladder carcinogens and the other major substances in the US study was analine which is not a bladder carcinogen the US estimate has been chosen for workers exposed to chemical and rubber manufacture (NACE codes 24 and 251). The risk estimate for other exposed workers has been set to 1.

2 BASELINE SCENARIOS

2.1 STRUCTURE OF THE SECTOR

The total worldwide production volume of o-toluidine was estimated to be between 4,500 and 23,000 tonnes in 2006. Production volume peaked in 1998 when it was estimated that between 23,000 and 46,000 tonnes were produced worldwide (IARC, 2010). In 2001 it was estimated that 60% of the total worldwide production of o-toluidine took place in Western Europe (see Table 2.1). If this is still the case then it is assumed that between 3,000 and 14,000 tonnes of o-toluidine are currently produced in Western Europe each year.[4] The available data indicates that European o-toluidine production is centred in France, Germany, Italy, the Netherlands, Switzerland and the United Kingdom (IARC, 2010). The available information suggests that there is no o-toluidine production in the rest of Europe.

Table 2.1 Estimated production volumes in 2001

Region	Estimated production volume (tonnes/year)
Western Europe (producers)	35,000
USA (1 producer)	10,000
China (5 producers)	12,000
India (1 producer)	2,000

Source: (Srour, 2002)

2.2 PREVALENCE OF O-TOLUIDINE EXPOSURE IN THE EU

The estimated exposure prevalence for the EU member states based on 2006 employment data is shown in Table 2.2. We have estimated that approximately 5,550 workers in the EU were potentially exposed to o-toluidine in 2006.

The prevalence of exposure to o-toluidine was estimated from the Finnish CAREX estimate of 2007. The Spanish CAREX estimate of 2004 and the Italian CAREX estimate of 2000 – 2003 did not estimate exposure to o-toluidine and were not used in

[4] OECD SIDS – o-toluidine. (2004)

our estimates.[5] The proportion of exposed workers from the Finnish 2007 estimate was applied to information on the number of employees in each industry obtained from the structural business statistics and the Labour Force Survey available on the Eurostat database (Korinth *et al*, 2007). The Finnish proportion of exposed workers was multiplied by the number of workers employed in each industry in each country.

The number of employees in some industry groups and countries was not available on the Eurostat database. Where possible, missing data has been substituted with 2005 or 2004 data for the applicable industry and country. When the 2005 and 2004 data were also unavailable we have indicated that data were unavailable for the industry and country.

The available data indicates that o-toluidine is not manufactured in Finland. As the prevalence estimates are based on estimates of the number of exposed workers in Finland, prevalence may be underestimated in countries where o-toluidine is manufactured (France, Germany, Italy, the Netherlands and the UK).

CAREX did not include any data on the prevalence of exposure to o-toluidine in the rubber manufacturing industry. Communication with the European Tyre & Rubber Manufacturers' Association (ETRMA) has indicated that rubber chemicals that can release o-toluidine as a thermal decomposition product (DOTG and DTPD) are used only in specific niche applications and that the majority of rubber manufacturing processes do not use these products. We have estimated that there are about 250 workers in the rubber manufacturing industry in the EU exposed to o-toluidine. The proportion of the total number of rubber industry workers in the EU in each member state was estimated from the Structural Business Statistics data and multiplied by 250 to estimate the number of exposed rubber industry workers by member state. The estimates made using this methodology are supported by the available published literature. Korinth *et al* (2007) described 51 exposed workers across three rubber manufacturing facilities in Germany; this figure is close to the 50 exposed workers estimated for Germany.

The estimated number of male and female employees in each industry group in each EU member state is also shown in Appendix 8.1. The estimates were obtained by applying the average male to female employee ratio for the industry group for each country to the total number of employees. Male to female employee ratios were calculated with data from the Labour Force Survey. Mangers, salespeople and office clerks were excluded from these calculations as they were assumed to be unexposed.

[5] *o-toluidine* and *o-toluidine* Hydrochloride. Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program. 2005

Table 2.2 Number of workers exposed to o-toluidine by country and NACE code

	NACE code Rev1						
	24	**251**	**73**	**75**	**80**	**85**	**Grand Total**
Austria	40	2	2	8	19	10	81
Belgium	105	2	2	13	33	14	169
Bulgaria	39	3	0	7	19	5	72
Cyprus	3	0	0	1	2	0	6
Czech Republic	62	15	2	10	25	9	123
Denmark	45	1	2	5	19	14	86
Estonia	4	0	0	1	5	1	12
Finland	27	2	1	3	15	11	59
France	413	46	13	72	158	83	785
Germany	687	50	30	86	185	114	1153
Greece	27	1	3	11	27	6	75
Hungary	48	7	2	9	28	8	102
Ireland	37	0	1	3	12	6	59
Italy	300	31	8	43	136	40	559
Latvia	7	0	0	3	8	1	19
Lithuania	9	0	0	2	12	3	27
Luxembourg	2	3	NA	1	1	1	7
Malta	NA*	0	NA	0	1	0	2
Netherlands	96	2	11	17	48	36	209
Poland	162	22	1	28	101	24	338
Portugal	32	4	0	11	28	9	84
Romania	73	9	7	15	37	11	152
Slovakia	19	4	1	5	15	4	49
Slovenia	21	2	1	2	7	2	34
Spain	209	20	5	37	95	33	399
Sweden	65	4	4	8	43	21	145
United Kingdom	322	19	33	61	226	99	760
TOTAL	**2855**	**250**	**131**	**460**	**1305**	**564**	**5565**

*NA = Not Available

Classification of Industries by Exposure Level

Industries in which exposure to o-toluidine occurs have been classified as high, medium, low or background exposure based on an evaluation of the peer-reviewed literature, information from industry and expert judgement. The industries, grouped by NACE code were identified from the CAREX data and the peer-reviewed literature. The exposure classification by industry is presented in Table 2.3.

Table 2.3 Classification of industries by exposure level

Industry	NACE (rev 1.1)	Historical Exposure Classification[1]	Number of People Exposed 2006[2]
Manufacture of chemicals, chemical products and man-made fibres	24	Medium	2855
Manufacture of rubber products	251	Medium	250
Research and development	73	Background	131
Public administration and defence	75	Background	460
Education	80	Background	1305
Health and Social Work	85	Background	564

[1] Relevant to 1975 exposure levels
[2] Prevalence estimation methods are described in section 1.3

2.3 LEVEL OF EXPOSURE TO O-TOLUIDINE

2.3.1 Estimation of exposure levels

Inhalation Exposure

- NACE 24 – Manufacture of chemicals, chemical products and man-made fibres

In the chemical industry exposure to o-toluidine can occur during its production and during its use in the production of herbicides, dyes and pigments, rubber chemicals, epoxy resin hardeners, fungicide intermediates, and pharmaceutical intermediates.

o-Toluidine appears to have been relatively well controlled in most chemical manufacturing facilities for the past several decades. Measurements from a dye manufacturing plant in the US from the 1940s indicated that exposures were below 0.7 ppm (Ott *et al*, 1983). In the early 1980s airborne concentrations of o-toluidine at another dye and pigment manufacturing facility ranged from 0.005 – 0.34 ppm.[6] However, higher exposure levels were reported at a chemical plant in the former USSR where o-toluidine was manufactured. Typical measured concentrations of o-toluidine at the Soviet plant ranged from 1.4 – 4.6 ppm but some measurements were as high as 6.6 ppm.[7]

Personal air monitoring measurements from 64 workers involved in rubber chemicals manufacturing at a US facility in 1990 found a mean air concentration of approximately 0.09 ppm (Ward *et al*, 1996).

The earliest available European exposure data comes from a 1992 UK study of 120 workers exposed to o-toluidine during its manufacture and use. The measured eight-

[6] OECD SIDS – o-toluidine. (2004)
[7] OECD SIDS – o-toluidine. (2004)

hour time-weighted average concentrations of o-toluidine ranged from 0.007 to 2.7 ppm however, only one measurement exceeded 0.3 ppm.[8]

More recent data suggests exposures in the EU remain at low levels and have likely decreased since the early 1990s. The Organisation for Economic Co-Operation and Development Screening Information Data Set (OECD SIDS) published in 2004 reported communication with one chemical manufacturing company with facilities in Germany where o-toluidine is manufactured and processed.[9] The company's regular monitoring program at its German sites indicated that concentrations of o-toluidine during manufacturing and processing were below the German Technical Exposure Limit (TRK) of 0.5 mg/m^3 (0.1 ppm).

The available data suggest that exposures in the chemical industry have been well below 1 ppm (4.4 mg/m^3) for the past 20 years and that approximately 98% of current exposures in the chemical industry are below 0.1 ppm.

- NACE 25.1 Manufacture of Rubber Products

Two studies of exposures among workers exposed to rubber chemicals in Germany found that exposures are typically below 0.1 ppm. In one study exposures ranging from 0.006 – 0.02 ppm were reported for four workers involved in rubber vulcanisation (Korinth *et al*, 2006). In the other study exposures ranged from <0.00001 – 0.12 ppm (median 0.006 ppm and mean 0.014 ppm) for 51 workers involved in the manufacture of rubber products for the automobile industry (including mixing of raw materials, finishing and assembling, vulcanisation, debarring and final inspection of products) (Korinth *et al*, 2007).

The available data suggest that all exposures in the rubber industry are below 1 ppm and that approximately 98% of exposures are below 0.1 ppm.

- NACE 73, 75, 80, 85 (Use of o-toluidine in laboratories)

The only available exposure estimates for the use of o-toluidine as a reagent in laboratories are from a 1984 EPA Chemical Hazardous Information Profile, which reported that laboratory and medical personnel were exposed to air concentrations of o-toluidine below 5 ppm (no range or means were given).[10] Kauppinen *et al* reported that in 1988 laboratories in Finland in which o-toluidine was used consumed medians of 10 and 180 g/year of o-toluidine for staining of tissues/reagents and glucose and xylose determinations respectively. The amount of o-toluidine used as a reagent in laboratories continues to be low and it is unlikely that sufficient quantities are used in EU laboratories to result in regular expose above 0.1 ppm. It is unlikely that any EU laboratory workers are regularly exposed to o-toluidine above 0.1 ppm.

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[8] International Programme on Chemical Safety. Concise International Chemical Assessment Document No. 7 : o-toluidine. Available at: http://www.inchem.org/documents/cicads/cicads/cicad07.htm#PartNumber:4
[9] OECD SIDS – o-toluidine. (2004)
[10] CHIP. 1984. Chemical Hazard Information Profile. Ortho-toluidine; ortho-toluidine Hydrochloride. Washington, D.C.: U.S. Environmental Protection Agency. Office of Pesticide Programs and Toxic Substances.

Change in exposure over time

The available data suggest that exposures have been at relatively low levels for the past 20 years however it does appear that during that time there has been some decline in exposure. A 1992 UK study found that 119 of 120 eight-hour time-weighted average exposure measurements were below 0.3 ppm[11] and a 2004 report indicated that all routine exposure measurements at German chemical manufacturing facilities belonging to one company were below 0.1 ppm.[12] Mean exposure levels are not available so it is not possible to estimate the precise decline in average exposure levels. However, if it is assumed that maximum exposure levels were 0.3 ppm and 0.1 ppm in 1992 and 2004 respectively the temporal trend in maximum exposure levels can be estimated by fitting an exponential regression equation of the form $y = a.e^{-bx}$ to the values. The regression coefficient can then be used to calculate the average annual change in maximum concentration over the period for which exposure was estimated.

The temporal trends were expressed as the annual change in exposure using the following expression:

$$\% \text{ change per year} = 100 * (\exp[b] - 1)$$

Over the period 1992 to 2004 an annual decline of 8.8% was estimated.

Dermal exposure

The aim of this study is to assess the impact of the introduction of an occupational exposure limit for inhalation exposure and consequently all of the analysis presented will focus on the risk of cancer from exposure by the inhalation route. However, it is important to note that dermal absorption is an additional route of exposure for o-toluidine. Lüersen *et al* (2006) demonstrated that o-toluidine passes quickly through the skin (lag-time <1 hour) and about 10% of the applied dose passes through the skin in 8 hours.

Few dermal exposure measurements are available but some studies have investigated exposure by the inhalation route indirectly through biological monitoring. Khlebnikova measured 0.01 – 0.03 mg o-toluidine per 100 cm^2 skin at a chemical manufacturing plant in the former USSR and published the results in 1970.[13] The air monitoring results from this same study indicated very high levels of exposure and the dermal measurements are also unlikely to be representative of current dermal exposure levels in the EU. No other dermal exposure measurements for o-toluidine were available.

Urine samples collected from workers at a US dye manufacturing facility in the 1940s showed a range of o-toluidine in urine of <0.3 mg/L – to 1.7 mg/L. The concentration of o-toluidine in air at the same facility was 0.5 ppm (2.19 mg/m^3). In 1990 o-toluidine

[11] International Programme on Chemical Safety. Concise International Chemical Assessment Document No. 7 : o-toluidine. Available at: http://www.inchem.org/documents/cicads/cicads/cicad07.htm#PartNumber:4
[12] OECD SIDS – o-toluidine. (2004)
[13] OECD SIDS – o-toluidine. (2004)

exposure was assessed at the rubber chemicals department of a US chemical manufacturing facility. An excess of bladder cases had been reported among workers at the facility. The results of air sampling at the facility indicated that personal inhalation exposure to o-toluidine was 0.094 ppm (standard deviation [SD]: 0.084 ppm). The mean post-shift urinary concentrations of o-toluidine among exposed workers was 99 µg/L (SD: 119.4 µg/L), much higher than the mean post-shift urinary concentration of 2.8 µg/L (SD: 1.4 µg/L) measured for unexposed workers. In a study published in 1995 Riffelmann *et al* reported urinary concentrations of o-toluidine from 45 workers at three German chemical manufacturing facilities. The time of sample collection (pre-, during, or post-shift) was not reported. The mean concentration of o-toluidine measured in urine was 0.6 µg/L (SD: 1.0, median: 0 µg/L) for exposed workers who were smokers and 0.4 µg/L (SD: 1.1, median: 0 µg/L) for exposed workers who were non-smokers. Air measurements were not taken (Riffelmann *et al*, 1995). In a study published in 2007, Korinth *et al* reported the results of biomonitoring of 51 exposed workers at three rubber manufacturing facilities in Germany. Inhalation exposure measured during the same study ranged from <0.00001 – 0.12 ppm (median 0.006 ppm and mean 0.014 ppm). The mean urinary concentration of o–toluidine for exposed non-smokers was 38.6 µg/L (range: <0.05 µg/L – 292.4 µg/L, median: 6.0) and for exposed smokers was 14.5 µg/L (range <0.05 µg/L – 242.9 µg/L, median: 0.6 µg/L) (Korinth *et al*, 2007). It is difficult to compare the results from the Riffelman study and the Korinth study as Riffelman *et al* (1995) did not take air measurements. However, the air measurements that were taken by Korinth *et al* (2007) showed low levels of inhalation exposure to o-toluidine at the rubber manufacturing facilities studied. This suggests that there may be more potential for dermal exposure to o-toluidine during rubber manufacturing than during chemical manufacturing.

Geometric mean (GM) and geometric standard deviation (GSD) urinary concentrations for the rubber and chemical manufacturing industries were estimated from the data reported by Korinth *et al* (2007) and Riffelman *et al* (1995) respectively using equations described by Lavoué *et al* (2007).

For the chemical industry we estimated the GM and GSD from the reported arithmetic means (AM) and arithmetic standard deviations (ASD) reported by Riffelman *et al* The available data was reported separately for smokers and non smokers and we used a mid-range AM value of 0.5 µg/L for the AM and an ASD of 1. The following equations were used to estimate GM and GSD:

To estimate GM from AM and ASD:

$$GM = \frac{AM}{\sqrt{1 + \frac{ASD^2}{AM^2}}}$$

To estimate GSD from AM and ASD:

$$GSD = \exp\sqrt{\ln(1 + \frac{ASD^2}{AM^2})}$$

For the chemical industry we have estimated a GM urinary o-toluidine concentration of 0.22 µg/L and a GSD of 3.6.

For the rubber manufacturing industry we estimated the GM and GSD from the reported AM and median from the Korinth *et al* study. The available data was reported separately for smokers and non-smokers. The relative proportion of smokers and non-smokers in the study was not reported so we took the average of the values for smokers and non-smokers for use in our estimates. We based our estimates on an AM of 26.55 µg/L and a median of 3.3 µg/L. Median values typically approximate the GM so we have assumed a GM of 3.3 µg/L. We estimated a GSD of 7.7 from the AM and GM using the following equation:

To estimate GSD from GM and AM:

$$GSD = \exp\sqrt{2 \times \ln(\frac{AM}{GM})}$$

In summary, for the rubber manufacturing industry we have estimated a GM urinary o-toluidine concentration of 3.3 µg/L and a GSD of 7.7.

Overall weighted GM and GSD estimates for Inhalation and Urinary Concentration

- Inhalation Exposure

The available data suggest that at least 98% of all current exposures in the EU are below 0.1 ppm. To estimate the overall geometric mean (GM) exposure level across all industries in the EU @Risk was used to simulate exposure distributions to identify a GM at which only 2% of workers are exposed above 0.1 ppm. A geometric standard deviation (GSD) of 3 is typical of occupational exposure distributions and therefore was used as the GSD in the simulations. The overall GM exposure level across the EU was estimated to be 0.01 ppm with a GSD of 3.

- Urinary Concentration

Overall weighted urinary concentration GM and GSD were estimated across both medium exposure industries: chemical manufacturing and rubber manufacturing. Using @Risk 10,000 “measurement” data points were generated using the GM for each industry. The number of “measurements” each industry contributed was weighted according to the estimated number of people exposed in that industry. The prevalence estimates presented in Table 1 was used as the number of exposed in each industry. The overall weighted GM was 0.276 µg/L with a GSD of 4.71

2.4 HEALTH IMPACT FROM CURRENT EXPOSURES

2.4.1 Background data

The occupational cancers associated with exposure to o-toluidine are shown in Table 2.4, along with a summary of the information used in the health impact assessment.

Table 2.4 Occupational cancers associated with exposure to o-toluidine

Cancer site	Bladder	
ICD-10 code	C67	
IARC group for carcinogen	2b	
Strength of evidence for cancer site (1)	-	
Latency assumption	10-50 yrs	
Source of forecast numbers - deaths	Eurostat, 2006	
Source of forecast numbers - registrations	GLOBOCAN, 2002[14]	
Exposure levels	Relative Risk (RR)	Source of RR
Chemical and rubber manufacture (M)	5.84 (2.91, 10.45)	Carreon *et al* (2010)
Other o-toluidine exposed workers (B)	1	default

(1) Based on Siemiatycki *et al*, 2004

2.4.2 Exposed numbers and exposure levels

Industry sectors, their NACE codes, classifications to High/Medium/Low/Background exposure as applicable for the mid 1970's and numbers exposed in 2006 are given in Table 2.3 in the previous section on the exposure. The estimated average exposure level (GM) and measure of variability (GSD) for those industries exposed to o-toluidine are 0.01 ppm and 3 respectively for 2010.

We present data for a "baseline" scenario which for all industries assumes an 8.8% annual decline in exposure levels and standard change in employed numbers up to the 2001-10 estimation interval and constant levels thereafter.

2.4.3 Forecast cancer numbers

Separate estimates for total numbers of deaths for bladder (C67) cancer by age band are available from EUROSTAT for the 27 countries of the EU, for 2006, and for registrations for bladder cancer from GLOBOCAN for 2002. The forecast numbers of deaths and registrations by country used to estimate attributable numbers are in Appendix 8.2.

2.4.4 Results

The cancer deaths and registrations attributed to occupational exposure to o-toluidine for the baseline scenario are presented per year for the target years given and are based on the all working age cohort of currently (2006) exposed workers. Attributable fractions and numbers of deaths and registrations, and Years of Life Lost (YLLs), Years Lived with Disability (YLDs) and Disability Adjusted Life Years (DALYs), are estimated.

As the exposure data suggests that exposure declines over time, a dynamic baseline scenario has been used.

A summary of the results for the total EU is in Table 2.5 below

[14] IARC, GLOBOCAN database, available at: http://www-dep.iarc.fr/globocan/database.htm

Table 2.5 Results for the baseline forecast scenario, total EU (27 countries), o-toluidine, men plus women[15]

Scenario	All scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	21,058	22,789	24,577	25,866	26,529	26,529
Proportion of the population exposed	0.006%	0.006%	0.006%	0.007%	0.007%	0.008%
Bladder cancer						
Attributable Fraction	0.0168%	0.0106%	0.0040%	0.0010%	0.0003%	0.0003%
Attributable deaths	7	5	2	1	0	0
Attributable registrations	22	16	7	2	1	1
'Avoided' cancers						
YLLs	81	60	26	7	3	3
DALYs	106	79	34	9	3	3

The attributable deaths and registrations in 2010 from past exposure to o-toluidine were low (7 and 22 cases, respectively). Over the next 50 years the health impact is predicted to decrease so that by 2060 there is one predicted registration and less than one death. The corresponding estimated attributable fraction for bladder cancer decreases from 0.0168% in 2010 to 0.0003% in 2060. Estimates for Years of Life Lost and DALYs also decrease so that by 2060 there are predicted to be 3 YLLs and 3 DALYs arising from o-toluidine exposures in Europe.

2.5 POSSIBLE COSTS ASSOCIATED WITH NOT MODIFYING THE DIRECTIVE

2.5.1 Health impacts – possible costs under the baseline scenario

Introduction

The health data (cancer registrations and Years of Life Lost - 'YLL') for the baseline in which there are no further modifications to the Carcinogens Directive are shown in section 2.4 of this report. These data show that there are predicted to be approximately 500 cancer registrations over the period 2010-2070[16] and around 1,800 YLLs over the period 2010-2070[16] from bladder cancer mainly resulting from historical exposure to o-toluidine. There is predicted to be a decline in registrations and YLLs over time as a result of predicted exposure reduction owing to implementation of existing and ongoing risk management measures across the EU.

Method in brief

Using the health data (cancer registrations and Years of Life Lost - 'YLL'), it is possible to monetise the costs under the baseline by estimating the:

[15] Deaths and registrations are rounded to the nearest whole number. Where YLLs/YLDs/DALYs appear in association with zero deaths/registrations, this is due to rounding the deaths/registrations down to zero.

[16] Note health estimates are provided for "snap-shot" years; 2010, 2020, 2030 etc. Results for a "snap-shot" year are assumed to be representative for the relevant time period (i.e. 2010 is also representative for 2010-2019) so impacts are multiplied by 10.

- Life years lost – This is calculated by using the YLL and multiplying this by a valuation of the Value of Life Year Lost (VLYL). This gives a value for the time (in years) lost as a result of premature death.
- Cost of Illness (COI) –This is a monetary cost of the time spent with cancer. In this study, a unit COI estimate is multiplied by the number of cancer registrations to give a total value for COI. (COI is often the main market-based approach in relation to health impact[17]). COI includes the direct and indirect costs of cancer but not the intangible costs (see below).
- Willingness to Pay (WTP) to avoid cancer – WTP in this study is used as an alternative method (high cost scenario) based on publicly available, peer reviewed studies on what people would be willing to pay to avoid having cancer. This includes various intangible costs (such as disfigurement, functional limitations, pain and fear) and includes the costs associated with life years lost.

The cost variables used in this study are presented in Table 2.6 in 2010 prices. For the purposes of this study, valuations are increased by 2% each year in the future in part to present costs in real terms (i.e. adjusting for inflation in prices) and to reflect the increasing value society attaches to its health (as economic growth typically increases over a long period of time)[18].

Table 2.6 Summary of cost variables used in this study (€ 2010 prices)

Cost/benefit elements	Low scenario	High scenario
VLYL - Each year lost	€ 50,393	€ 0 (note 1)
COI or WTP - Unit cost (per cancer registration)	€ 49,302 (COI)	€ 1,793,776 (WTP)

(Note 1) – By using WTP (€1.8m) in the high scenario instead of COI, the WTP can include the costs of premature death and therefore there was a risk of double counting benefits if VLYL costs were included.

All costs and benefits over time in this study are discounted using a 4% discount rate as recommended by the European Commission's Impact Guidelines[19]. In order to assess the effect that discounting has on the results ('sensitivity analysis), we have also presented estimates that take into consideration a declining discount rate for impacts occurring after 30 years and no discounting.

The health data shown in section 2.4 are 'snap-shots' (i.e. an estimation for the initial year of a ten year period) of the number of cancer registrations, deaths, YLLs in future years at 10 year intervals. In calculating the costs associated with these effects, each

[17] ECHA (2008) "Applying SEA as part of restriction proposals under REACH" Available at: http://echa.europa.eu/doc/reach/sea_workshop_proceedings_20081021.pdf

[18] This is consistent with some other European Commission studies and is standard practice for air quality under the Clean Air for Europe (CAFE) programme.

[19] European Commission impact Assessment Guidelines (Jan 2009) - http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_en.pdf

'snap-shot' result is multiplied by 10 in order to derive an estimate for the whole assessment time period (for example, 2020 results are multiplied by 10 to give results over the period 2020-2029). This assumes that each snap-shot year is representative of the following 10 years.

The method to valuing health benefits is explained in more detail in the method paper titled *"Valuing health benefits – Method paper".*

Results

The health costs under the baseline scenario are presented in Table 2.7. Health-related costs are predicted to decline over time and are predominately the result of past exposure. In Section 2.4 the number of cancer registrations and YLLs are estimated to decline over time, accounted for by risk management measures (RMMs) already imposed (as applied at production and end use) over the past 10-20 years.

The introduction of an EU-wide OEL is not expected to have a significant impact in the short term given that many Member States already have a national OEL in place (the stringency varies by Member State) and in the longer-term, the health costs are only moderate compared to other substances. Table 2.7 sets out the ranges of health costs for each representative decade. The ranges are based on the high and low cost scenarios (see Table 2.6). The results are also illustrated in Figure 2.1.

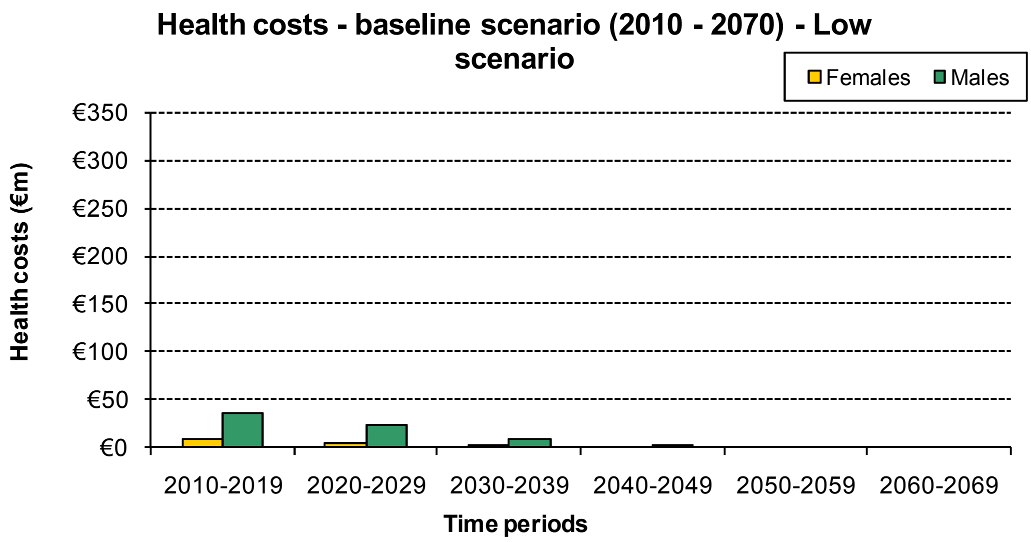
Table 2.7 Health costs - baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

Costs by Gender (€m)	**2010-2019**	**2020-2029**	**2030-2039**	**2040-2049**	**2050-2059**	**2060-2069**	**Total**
Female	8 to 56	5 to 34	2 to 12	0 to 3	0 to 1	0 to 1	16 to 107
Male	36 to 308	22 to 190	8 to 69	2 to 16	1 to 4	0 to 4	70 to 590
Total	45 to 364	28 to 223	10 to 81	2 to 18	1 to 5	1 to 4	86 to 696

Notes:

- All costs are presented in present value using a discount rate of 4%. The low range is based on low estimates for costs of illness and life years lost. The upper range of costs relate to WTP estimates to avoid having cancer, which include intangible costs associated with having cancer.

- Totals may not match to sums of females and male costs due to underlying small differences in raw data and rounding to whole number



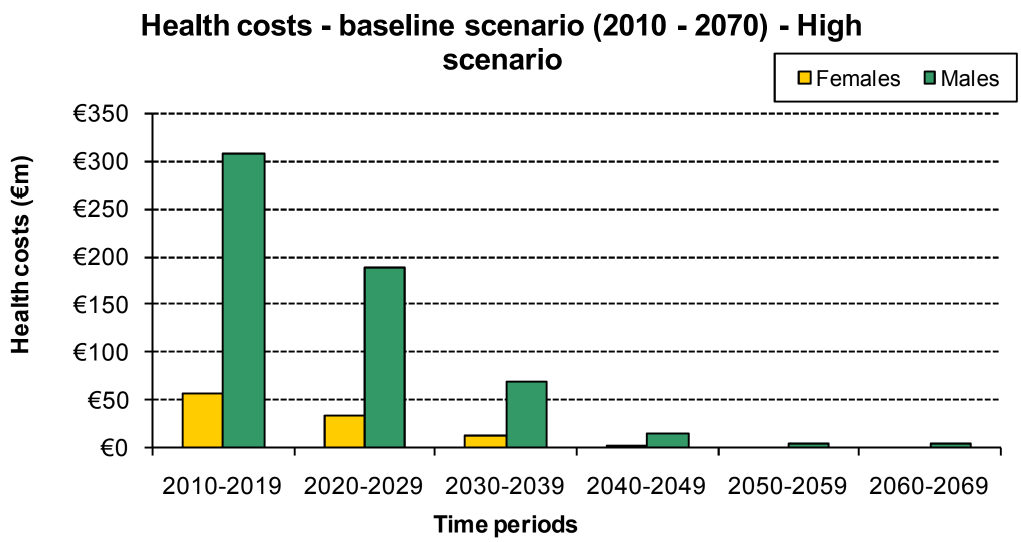


Figure 2.1 Health costs - baseline scenario – 2010 to 2070 (Present Value – 2010 €m prices)

These costs will affect Member States differently depending upon the overall number of workers within affected industry groups, existing RMMs and the proportion of males and females within these groups. Figure 2.3 shows that France, Germany, Italy, and the UK are predicted to have relatively high health costs. The industrial sector estimated to be most affected under the baseline is the manufacture of chemicals, chemical products and man-made fibres sector. The rubber manufacturing sector is affected less, due to the smaller numbers of people exposed. This is shown in Figure 2.4.

Detailed tables are included in Appendix 8.3.

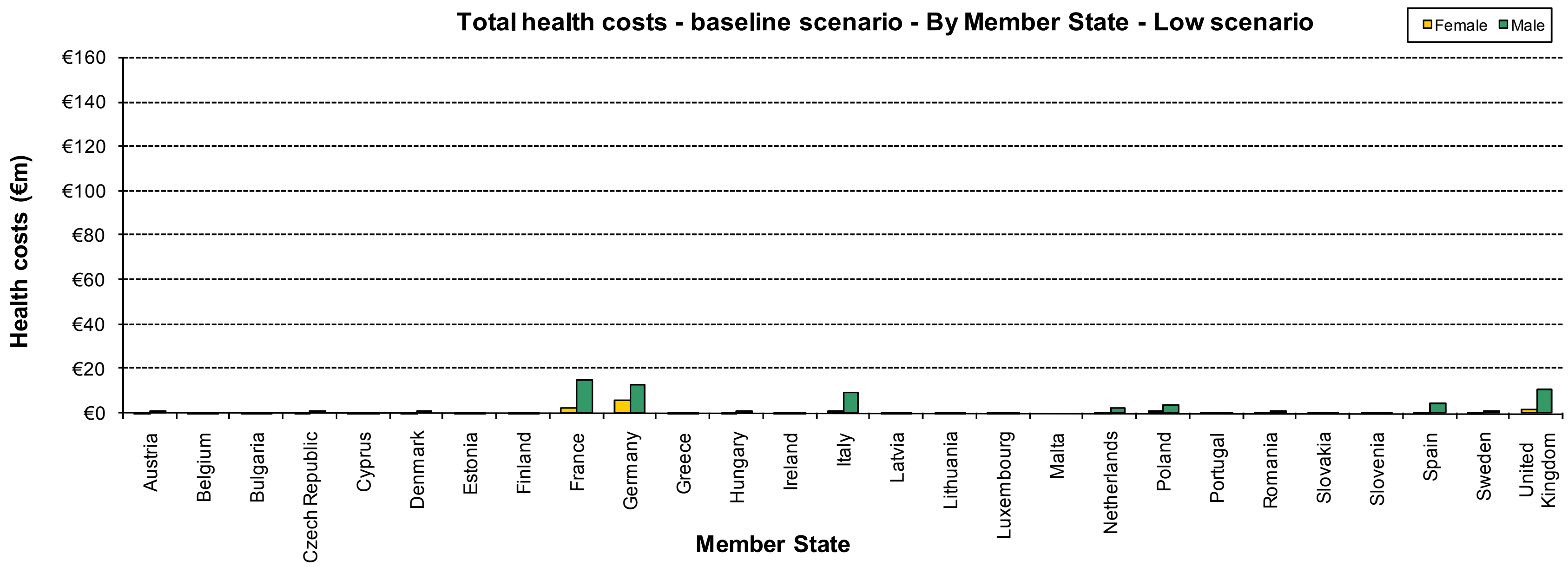


Figure 2.2a Total health costs- baseline scenario – By Member State (Present Value – 2010 €m prices)

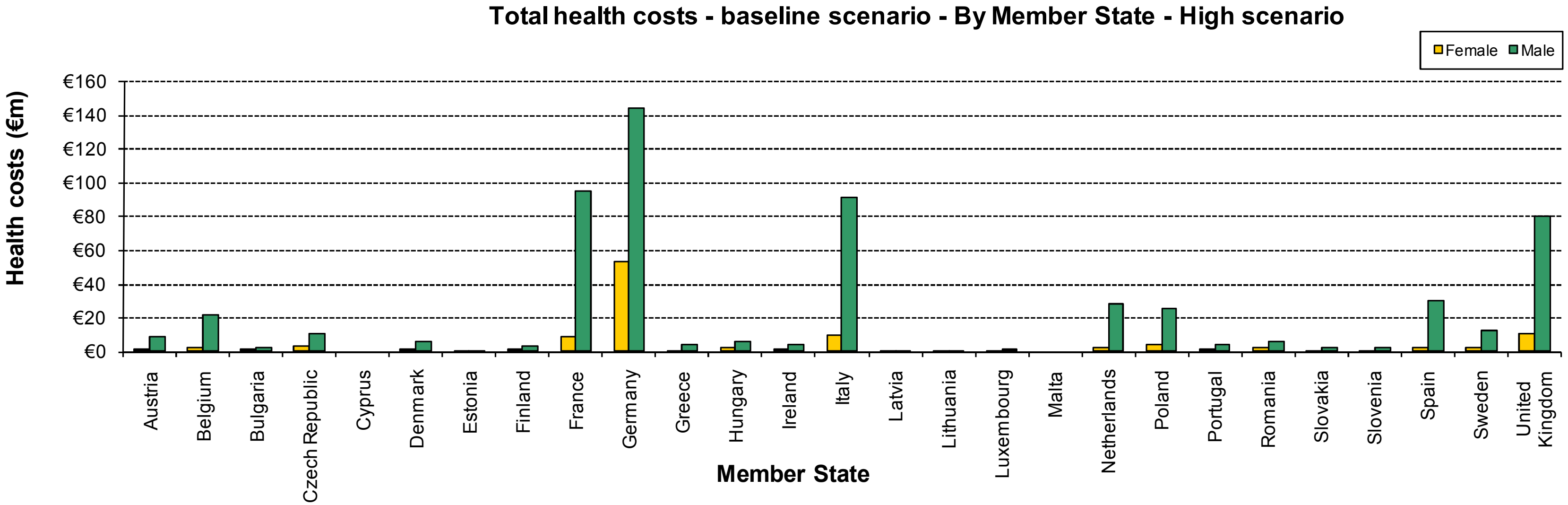
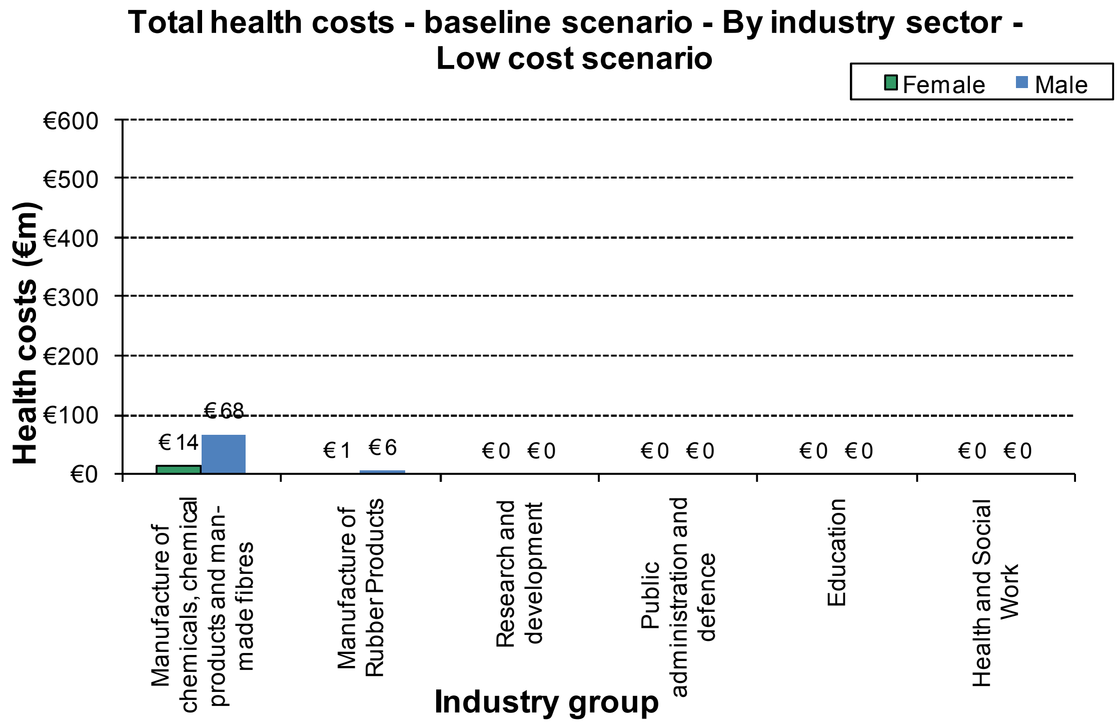


Figure 2.3b Total health costs- baseline scenario – By Member State (Present Value – 2010 €m prices)



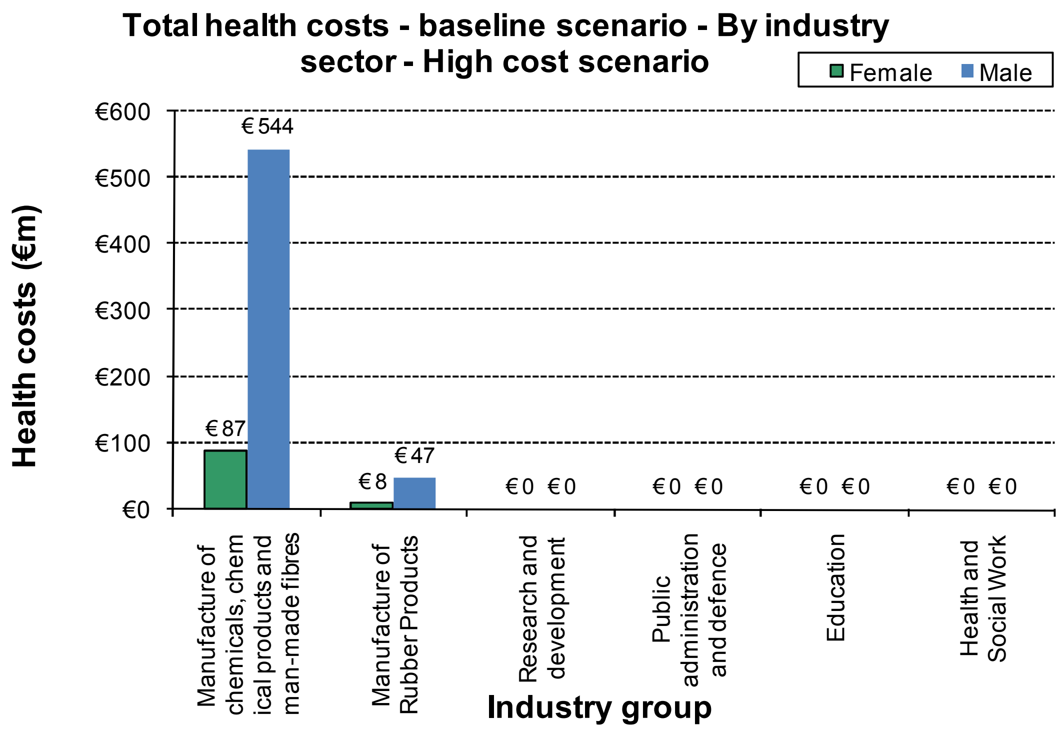
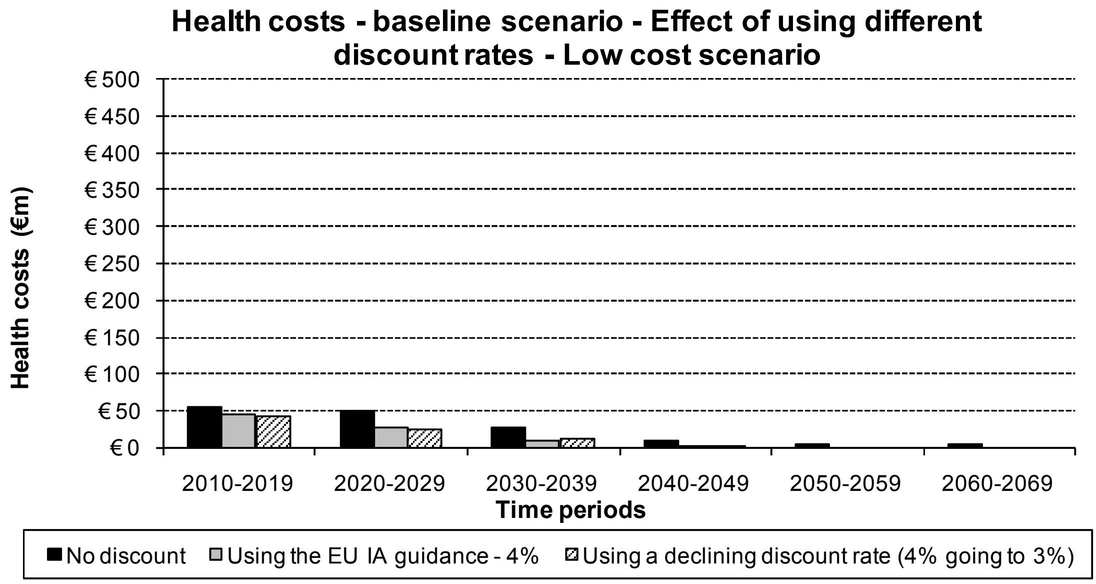


Figure 2.4 Total health costs - baseline scenario - by industry group (Present Value – 2010 €m prices)

In order to present all socio-economic costs and benefits consistently in present value terms, all future costs and benefits have been discounted. The primary approach was to apply the European Commission IA recommended 4% discount rate. Since most health impacts occur over a long period of time relative to costs, the impacts of discounting are significant.

In Figure 2.5, the effects of different discount rates on the overall results are shown, indicating that the impacts of discounting become more pronounced the further in the future that the impact occurs. As the number of registrations and YLLs decline over time, the difference between using discounting and with no discounting becomes less evident.



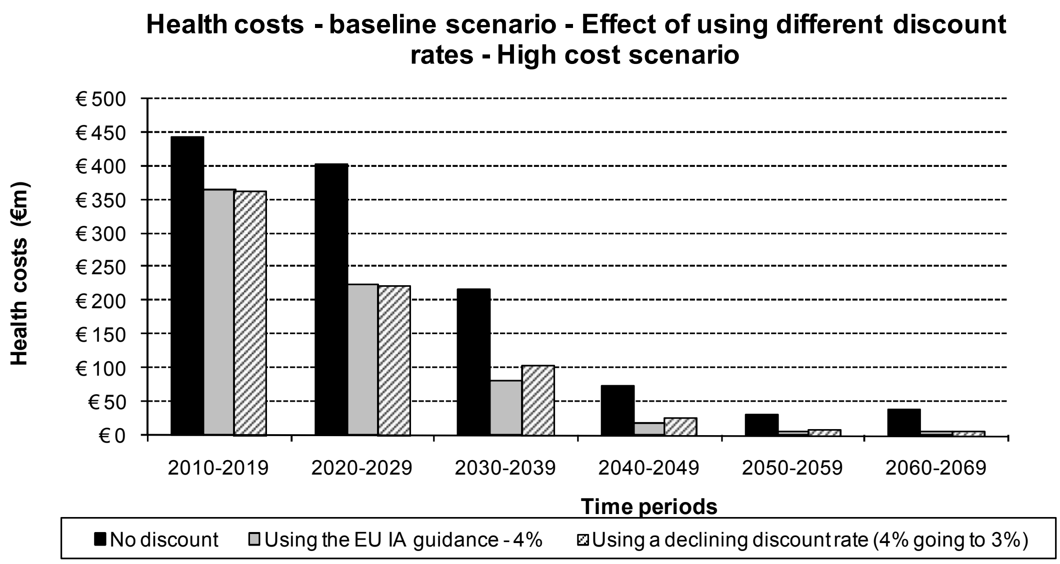


Figure 2.5 Impacts of discounting

3 POLICY OPTIONS

3.1 DESCRIPTION OF MEASURES

The policy options investigated in this report concern the potential implementation of an EU-wide OEL of 0.1 and 1ppm.

Occupational exposure to o-toluidine is most likely to occur through inhalation and dermal contact.[20] Reduction in exposure to o-toluidine can be achieved by the combination of different factors, as summarised in Table 3.1.

Table 3.1 Potential measures to reduce exposure to o-toluidine

Organisational measures	Hygiene measures	Technical measures	Substitution
O-toluidine should be manufactured and processed in closed systems	Use of appropriate RPE	Adequate ventilation system	Substitution of o-toluidine derived rubber chemicals
	Use of protective clothing		
	Avoid prolonged skin contact with substance		
	Improve employee behaviour		

Source: CICADS (1998)[21]; OECD SIDS (2004)[22]; NTP RoC (2005)[20]

3.2 LEVEL OF PROTECTION ACHIEVED (OELS)

In the chemical manufacturing industry o-toluidine is manufactured and processed in closed systems. At the chemical manufacturing company cited in the OECD-SIDS report regular sampling of enclosed systems is carried out to detect leakage and equipment is emptied of o-toluidine and flushed with water prior to repair and maintenance work. Where necessary protective clothing and respiratory protective equipment are used to control exposure. Note the exposure estimates described above do not take account of the protective effect of respiratory protection.

In the rubber industry exposure to o-toluidine has been eliminated in most companies by the substitution of o-toluidine derived rubber chemicals with other products. Among companies that do use o-toluidine derived rubber chemicals, exposures are typically

[20] National Toxicology Program Report on Carcinogens (RoC), Eleventh Edition (2005): o-toluidine and o-toluidine hydrochloride. Available online: http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s178otol.pdf

[21] International Programme on Chemical Safety. Concise International Chemical Assessment Document No. 7 : o-toluidine. Available at: http://www.inchem.org/documents/cicads/cicads/cicad07.htm#PartNumber:4

[22] OECD SIDS – o-toluidine. (2004)

controlled through the use of gloves. Korinth *et al* (2006) found that the use of skin barrier creams enhanced the percutaneous absorption of o-toluidine and these products are not recommended for workers who may be exposed to o-toluidine.

4 ANALYSIS OF IMPACTS

4.1 HEALTH IMPACTS FROM CHANGES TO THE EU DIRECTIVE

4.1.1 Health information

For o-toluidine, OELs of 0.1 and 1 ppm are to be tested. Bladder cancer numbers will therefore be estimated given full compliance[23] to these OELs. As set out previously, the baseline for all industries assumes an 8.8% annual decline in exposure levels and a standard change in employed numbers up to the 2021-30 estimation interval and constant levels thereafter.

We present data for two "intervention" scenarios as described in Table 4.1 below, compared to the baseline scenario described in section 2.4.1.

Table 4.1 Baseline and intervention scenarios

Intervention scenarios[(1)]	
Baseline scenario (1)	Current (2005) employment and exposure levels are maintained.
Intervention scenario (2)	Full compliance for OEL = 0.1 ppm
Intervention scenario (2)	Full compliance for OEL = 1 ppm

[(1)] All intervention scenarios are estimated as change to (1) the baseline scenario

A summary of the results for bladder cancer for the total EU is in Table 4.2 below. Due to cancer latency, no effect could be observed from interventions in 2010 until after 2030.

The data for the first two time periods (2010, 2020) are identical for both intervention scenarios, and then the data for both of the interventions are shown in the next two groups of four columns (2030-2060). Attributable deaths for bladder cancer are predicted to decrease from 7 deaths in 2010 to zero deaths for both scenarios. Neither intervention has any important effect over the assumed baseline scenario.

[23] Full compliance is assumed in the intervention scenarios; however, due to modelling restrictions full compliance is modelled as 99% compliance.

Table 4.2 Results for the intervention scenarios, total EU (27 countries), men plus women[24]

Scenario	All scenarios		Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
EU Total	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**	**2030**	**2040**	**2050**	**2060**
Numbers ever exposed	21,058	22,789	24,577	25,866	26,529	26,529	23,959	24,631	24,678	24,017
Proportion of the population exposed	0.006%	0.006%	0.006%	0.007%	0.007%	0.007%	0.006%	0.006%	0.006%	0.006%
Bladder cancer										
Attributable Fraction	0.017%	0.011%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%
Attributable deaths	7	5	2	1	0	0	2	1	0	0
Attributable registrations	22	16	7	2	0	0	7	2	1	1
'Avoided' cancers[25]			0	0	0	1	0	0	0	0
YLLs	81	60	26	7	1	0	26	7	3	3
DALYs	106	79	34	9	1	1	35	21	40	63

In Table 8.4.1 in Appendix 8.4 are the estimated proportions exposed above the OELs to be tested, currently and as estimated under the baseline scenario (1). Under the alternative change scenarios they behave as determined by the scenarios. For o-toluidine the results were adjusted to take into account the fact that the estimates of GM and GSD were specifically for 2010 (for other reports the estimated H/L boundaries and therefore proportions exposed above the OELs were based on GMs and GSDs that were assumed to apply in 2005, to represent the 2001-10 estimation interval).

Full results are given in Appendix 8.4 for men plus women by country in Table 8.4.2 and 8.4.3. A breakdown of attributable numbers by industry is in Table 8.4.4 and 8.4.5. Estimates of numbers of cancer registrations ‘avoided’ in each of the forecast target years from 2030 onwards relative to the baseline scenario can be obtained by subtraction. Data for men and women separately, and by industry within country, are available in supplementary spreadsheets (*O-toluidine Report data.xls)* if required.

[24] Deaths and registrations are rounded to the nearest whole number. Where YLLs/YLDs/DALYs appear in association with zero deaths/registrations, this is due to rounding the deaths/registrations down to zero.

[25] Using our calculation methodology a negative value for 'avoided' cancers can occur where the assumption of 99% compliance is lower than the compliance actually achieved due to the forecast (baseline) fall in exposure levels, which was the cased for o-toluidine for the 1ppm OEL intervention. In these cases zero 'avoided' cancers have been substituted for the negative values, i.e. we assume the intervention is identical to the baseline.

4.1.2 Monetised health benefits

The possible health benefits (i.e. avoided healthcare costs and effects of having cancer) for the introduction of an EU wide OEL at 0.1ppm and 1ppm are shown in Table 4.3. The change in cancer impacts over the first 30 years (2010-2040) are predominately the result of chronic impacts from past exposure as well as short term acute impacts that are predicted to continue to occur in the future (these are relatively small). The benefits of introducing an OEL in 2010 are therefore limited.

Table 4.3 indicates that there are estimated to be zero benefits of introducing an OEL of 1ppm because exposure is generally already controlled well below this level. There is only estimated to be a very small benefit to introducing an EU wide OEL of 0.1ppm. The impacts of introducing this more stringent OEL are estimated to have limited benefits as there is already estimated to be a reduction towards 0.1ppm and below under the baseline scenario (only 2% of exposed workers are estimated to be exposed above this level and exposure levels are declining). The results are also illustrated in Figure 4.1.

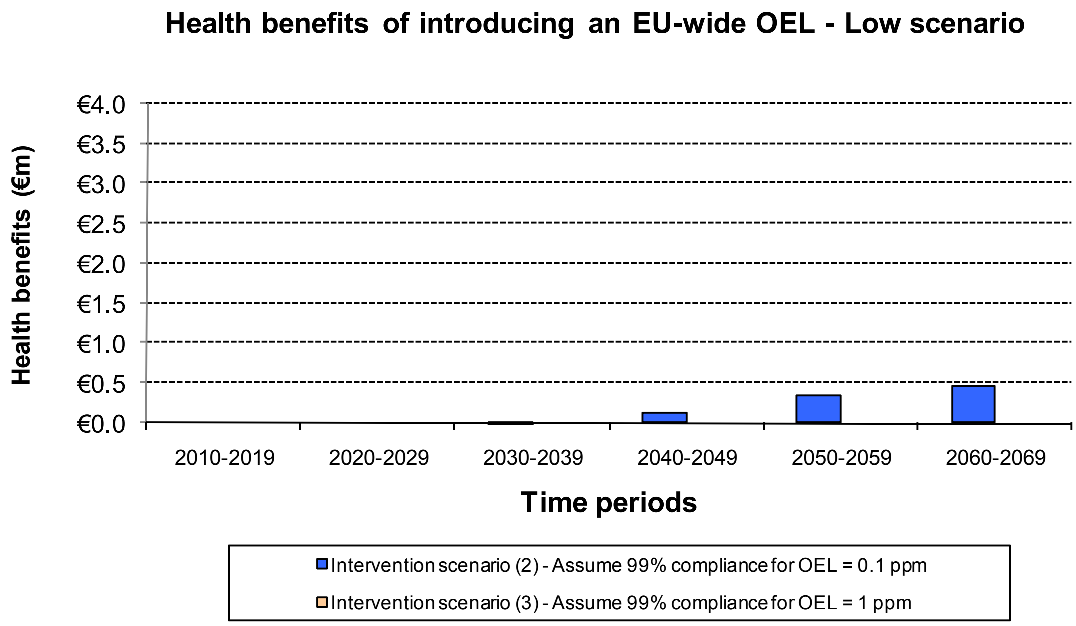
Table 4.3 Health benefits of intervention over time (Present Value – 2010 €m prices)

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069	Totals
Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm							
Female	0 to 0	0 to 0	0 to 0	0 to 0.2	0.1 to 0.4	0.1 to 0.6	0.2 to 1.2
Male	0 to 0	0 to 0	0 to 0	0.1 to 0.9	0.3 to 2.4	0.4 to 3.1	0.8 to 6.5
Total	0 to 0	0 to 0	0 to 0	0.1 to 1.1	0.4 to 2.8	0.5 to 3.7	1 to 7.6
Intervention option 2 - Assume 99% compliance for OEL = 1 ppm							
Female	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
Male	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
Total	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0

Notes:

- All costs are presented in present value using a discount rate of 4%

- Totals may not match to sums of females and male costs due to underlying small differences in raw data and rounding to nearest million



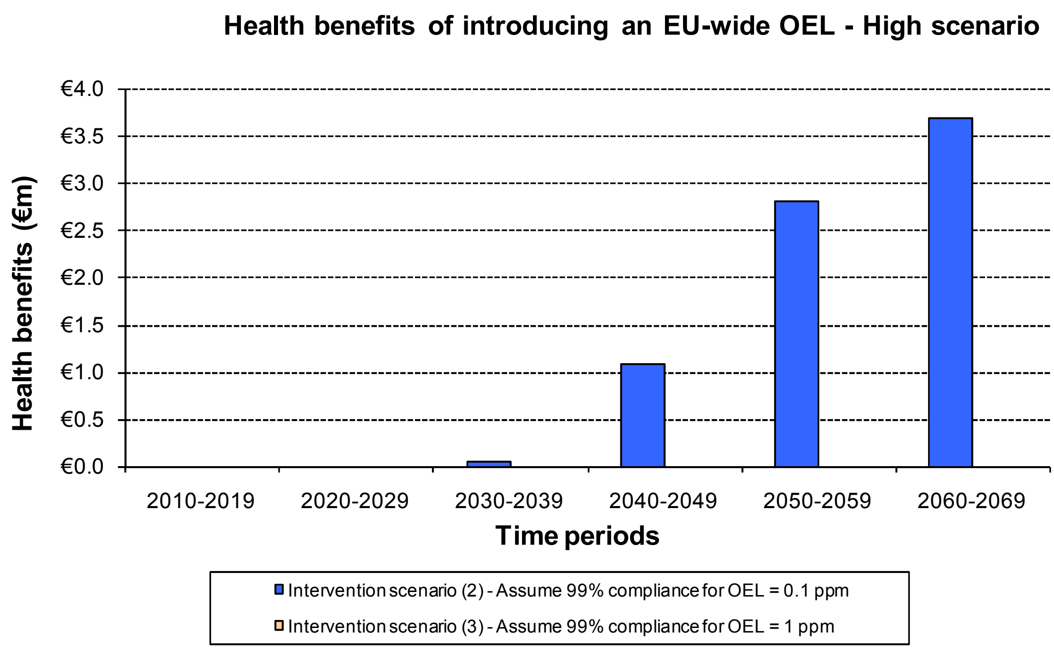


Figure 4.1 Health benefits over time of introducing an EU wide OEL (Present Value – 2010 €m prices)

These benefits will affect Member States differently depending upon the overall number of workers within affected industry groups, existing risk management measures (RMMs) and the proportion of males and females within these groups. The total benefits by Member State are shown in Figure 4.2 (low scenario) and Figure 4.3 (high scenario), where France, Germany, Italy and Spain are predicted to particularly benefit from the OEL assuming full compliance[26].

The monetised benefits of an EU-wide OEL for o-toluidine are likely to affect men more than women given the industrial sectors most exposed to the substance. The industrial sector estimated to benefit most from an EU-wide OEL (and full compliance) is the manufacture of chemicals. This is shown in Figure 4.4 (low scenario) and Figure 4.5 (high scenario).

The Member States and industry groups that are predicted to benefit most from a revised OEL also vary at a gender level. This analysis is presented in Appendix 8.5.

[26] The assumption of full compliance is a standard assumption used in EU Impact Assessments.

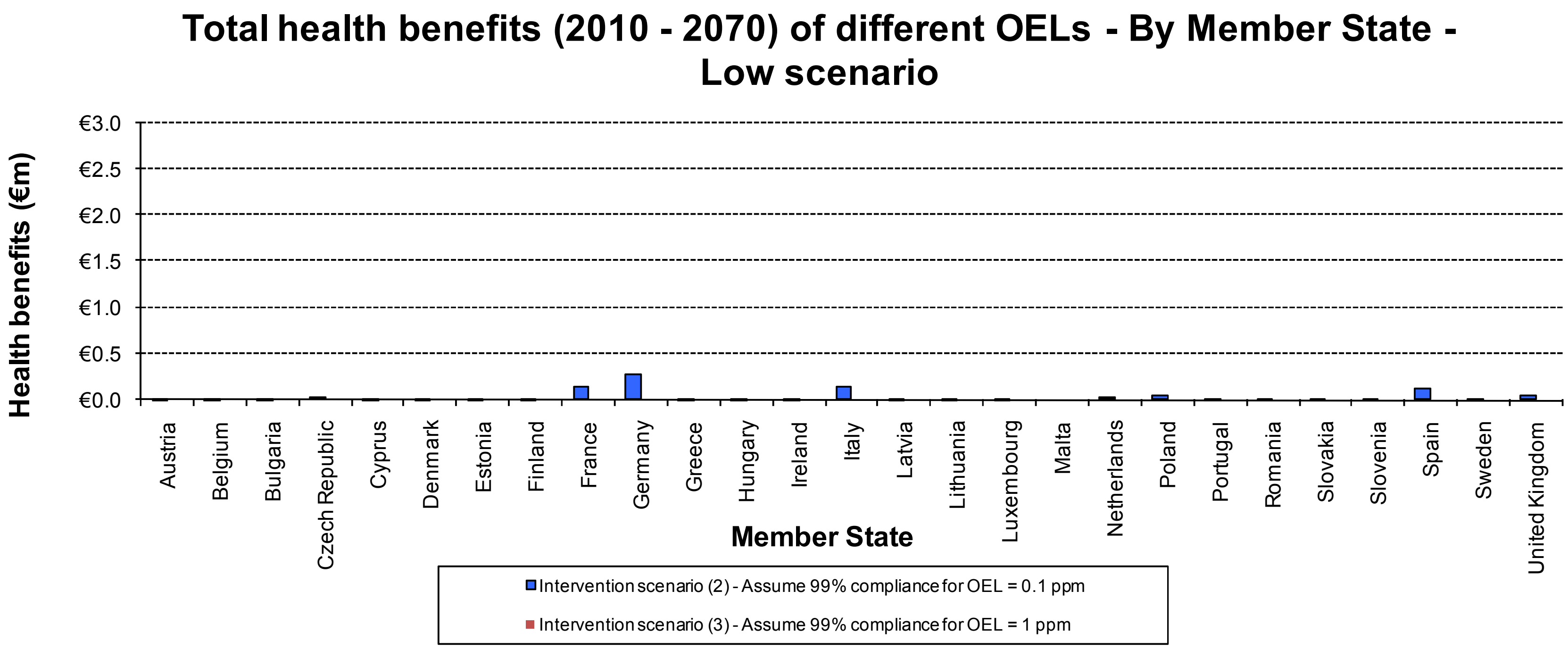


Figure 4.2 Total health benefits of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

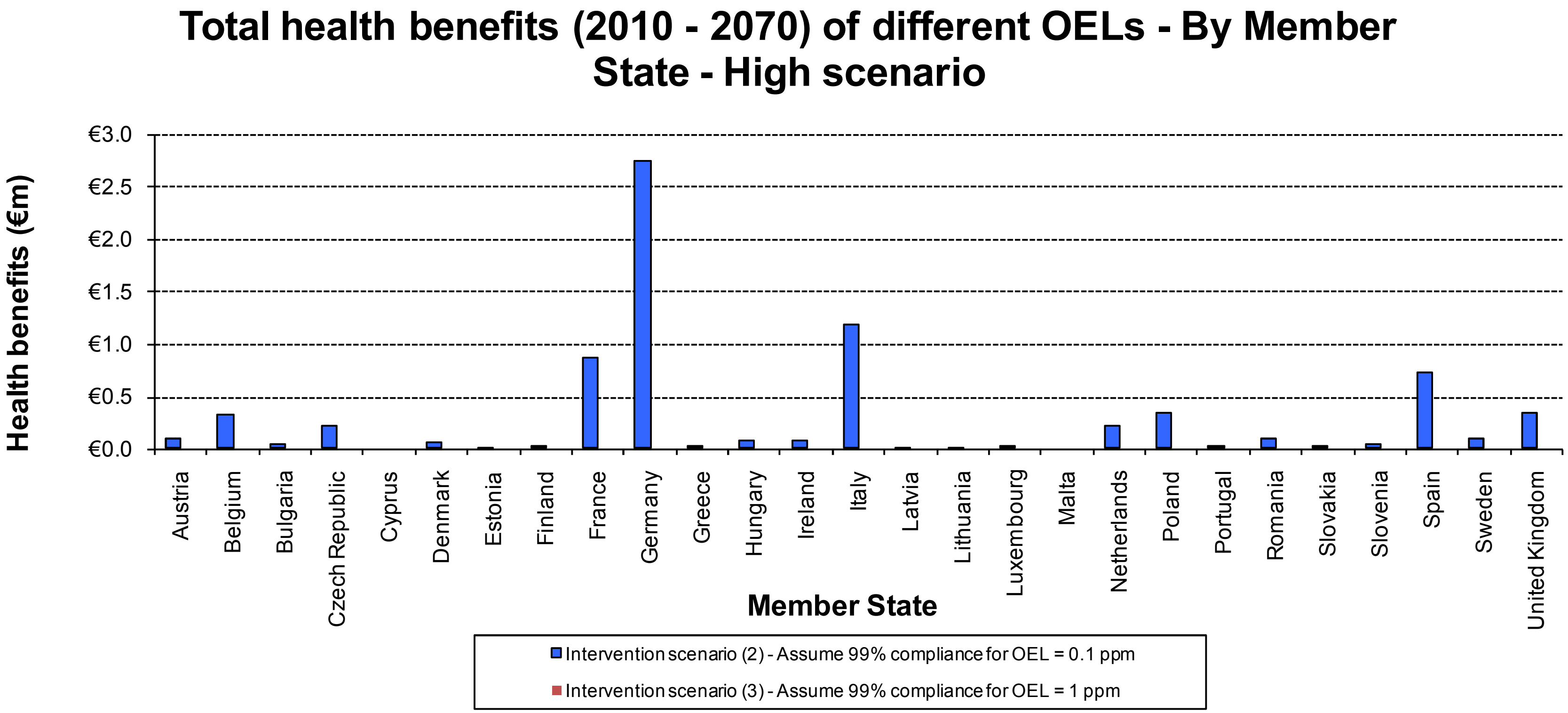


Figure 4.3 Total health benefits of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

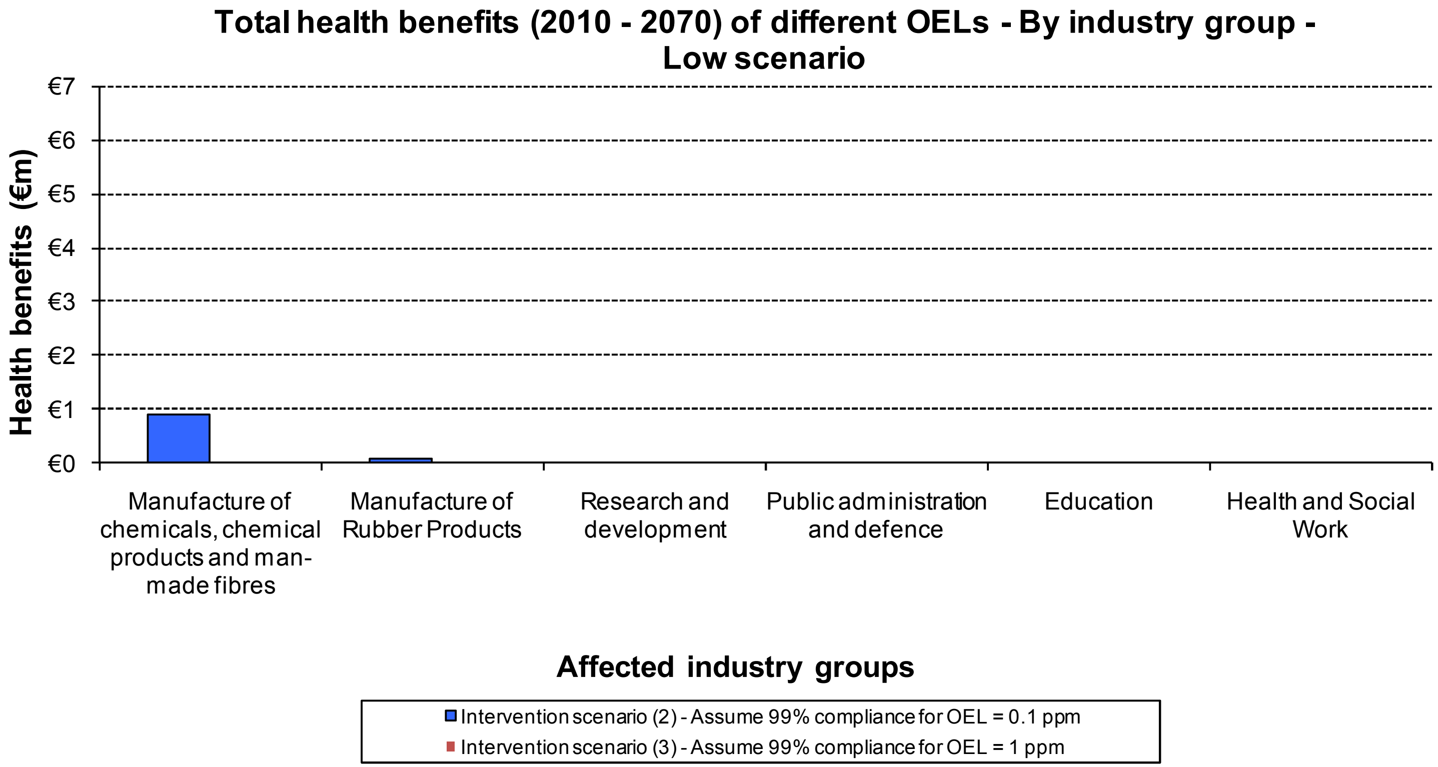


Figure 4.4 Total health benefits of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

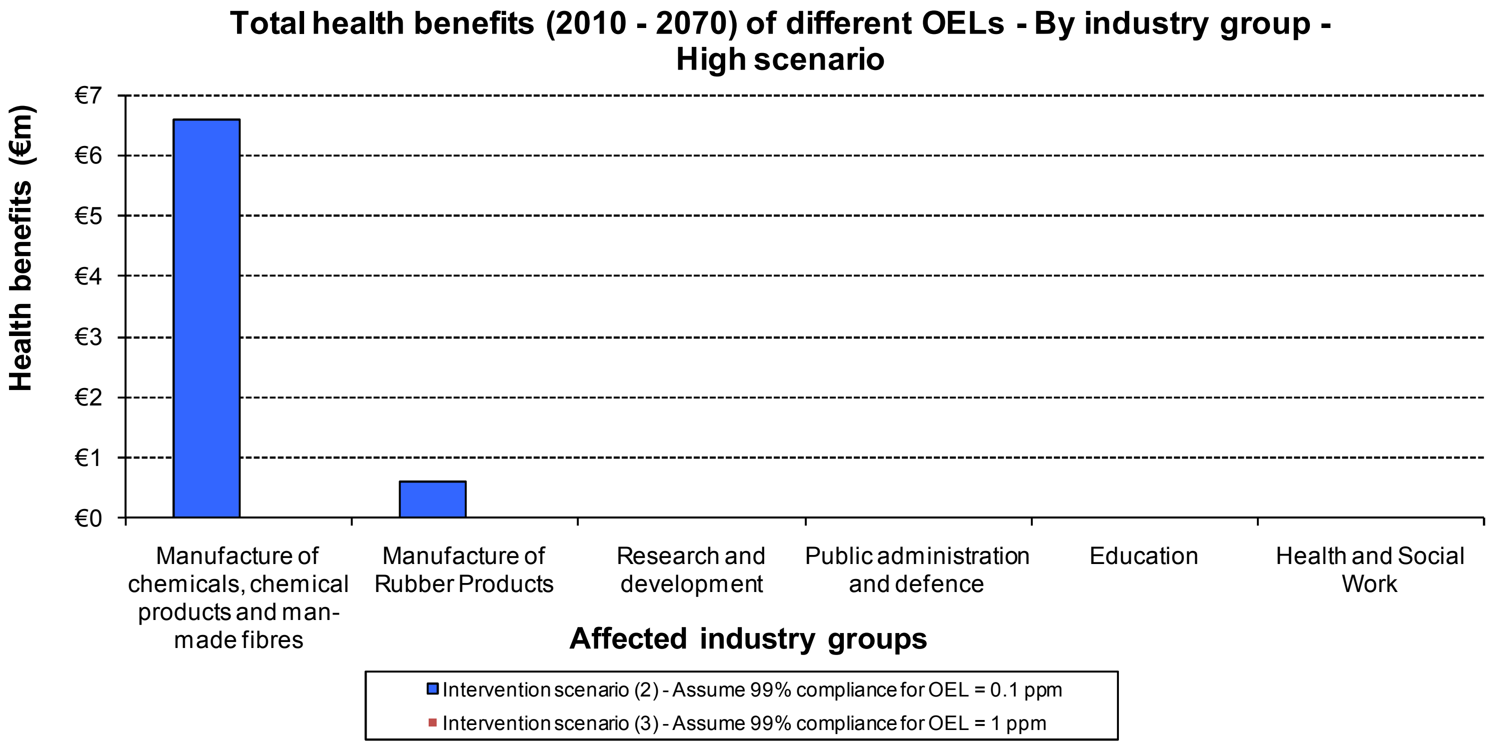


Figure 4.5 Total health benefits of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

As with the baseline scenario, in order to present all costs and benefits consistently in present value terms, it is necessary to discount all future costs and benefits. This was done using the IA guidelines recommended 4% discount rate. Since most health impacts occur over a long period of time relative to costs, the impacts of discounting are significant. As a means of sensitivity testing, different discount rates are also used. The overall impact of discounting can be seen in Figure 4.6 for introducing an OEL of 0.1ppm. As shown in Table 4.3 there are not predicted to be any benefits resulting from the implementation of an EU-wide OEL at 1ppm. The results are estimated to be the same even when discounting is not applied.

Detailed tables are included in Appendix 8.6, with results presented using different discount rates.

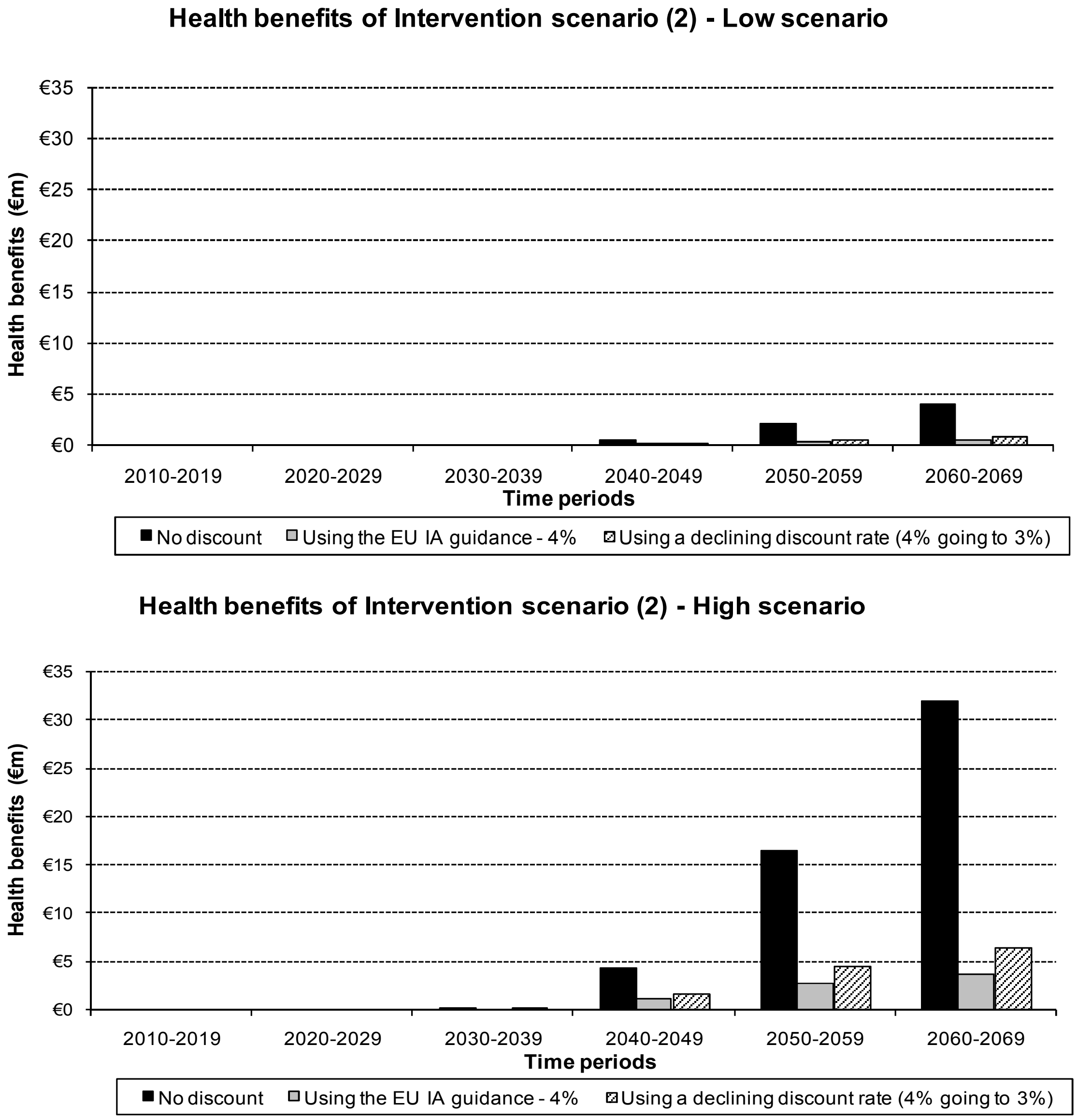


Figure 4.6 Impacts of discounting – Introducing an OEL of 0.1ppm

Since the benefits of introducing a more stringent OEL are almost all realised from 2040, the level of discounting has a significant impact on the overall size of health benefits. A limitation is that the benefits of any RMMs undertaken post 2040 will not be included in this study, since the benefits of these measures to reduce occupational exposure in 2040-2070 are unlikely to be realised until after 2070 (due to the lag period) which is not estimated in this study.

4.2 ECONOMIC IMPACTS

As set out in Section 2.3.1 there are risks of both inhalation and dermal exposure associated with o-toluidine. This section will consider the economic costs associated with the compliance of an airborne OEL to reduce inhalation exposure. Although a specific EU-wide biological monitoring value (BMGV) has not been proposed we have estimated the possible economic costs associated with reducing dermal exposure in line with the substance being assigned a skin notation, e.g. provision of protective gloves for some work tasks.

4.2.1 Operating costs and conduct of business

Number of firms affected

In Section 2.2 it was estimated that there are approximately 3,100 workers typically exposed to o-toluidine in the EU in medium exposure enterprises (NACE code 24 and 251). Based on exposure data presented in Section 2.3.1, it is reasonable to assume that:

- All firms in the manufacture of chemical products and the manufacture of rubber products (NACE code 24 and 251) would meet the least stringent proposed OEL (1ppm)
- Some firms in both these sectors would fail to meet the most stringent proposed OEL (0.1ppm) given that it is calculated that approximately two per cent of exposures are above 0.1ppm.

Using the estimates of the number of workers exposed and Eurostat data on the distribution of firms by size (based on number of employees per enterprise) it was possible to broadly estimate the number of enterprises requiring further action to comply with each proposed OEL.

The following tables (Table 4.4 and Table 4.5) set out the number of firms affected (by size and NACE code) for each proposed OEL. In total there is expected to be around:

- 9 firms affected by an EU-wide OEL at 0.1ppm
- no firms affected by an EU-wide OEL at 1ppm

Table 4.4 Number of enterprises affected in NACE code 24

NACE 251 **No: of employees bands**	**Average composition of enterprises for all affected NACE sectors**	**0.1ppm** **No of enterprises affected**	**1ppm** **No of enterprises affected**
Between 1 and 9	58%	7	0
Between 10 and 19	14%	1	0
Between 20 and 49	12%	0	0
Between 50 and 250	12%	0	0
Greater than 250	5%	0	0
Total affected	**-**	8	0
Percentage of affected firms relative to total number of firms in the sector	-		

Table 4.5 Number of enterprises affected in NACE code 1

NACE 23 **No: of employees bands**	**Average composition of enterprises for all affected NACE sectors**	**0.1ppm** **No of enterprises affected**	**1ppm** **No of enterprises affected**
Between 1 and 9	61%	1	0
Between 10 and 19	14%	0	0
Between 20 and 49	11%	0	0
Between 50 and 250	10%	0	0
Greater than 250	4%	0	0
Total	-	1	0
Percentage of affected firms relative to total number of firms in the sector	-	0.01%	0%

As shown above it is estimated that only a very small number of enterprises (probably fewer than 10) would be affected by the introduction of an EU-wide OEL of 0.1ppm.[27] Furthermore, as set out in Section 2.3.1, the number of firms with exposure currently exceeding the possible OEL is expected to fall even further over time as exposure is expected to decline at 8.8% per year.

Compliance Costs

As discussed in Section 3.1, it is thought that there are a number of control measures, PPE, enclosure of reactions and effective ventilation (general dilution or local exhaust

[27] This is just indicative but does show that because only a small number of people are likely to be exposed above the OEL, the number of firms affected will also be low.

ventilation - LEV), that can be implemented to limit inhalation and dermal exposure to o-toluidine. The specific control measures required by enterprises to comply with an OEL would depend on existing measures in place and the specific nature of operations conducted. Consultation with producers of o-toluidine suggests that occupational exposure can be reduced in two ways:

1. Increase the flow rate of ventilation – this will depend on the power of the existing system. If the power cannot be increased a new ventilation system may be required.
2. Improve employee behaviour – training courses can be operated to train employees.

Dilution ventilation is the dilution of contaminated air with uncontaminated air for the purpose of controlling potential airborne health hazards, fire and explosive conditions, odours and nuisance type contaminants. Local exhaust ventilation (LEV) systems capture and remove process emissions at or close to their source of generation and prior to their escape into the workplace environment. Ventilation systems generally involve a combination of these types of systems (OSHA, 1999). For example, a large LEV system may also serve as a dilution system. Table 4.6 shows estimates of costs for ventilation units based on information from ventilation suppliers. Costs per unit for o-toluidine industries are increased as exhaust equipment requires systems in place to remove the vapour from the air before it is discharged, which is more costly than in a standard system (see note 2 in Table 4.6).

Table 4.6 Capital costs per enterprise for ventilation units for stationary LEV

Type of cost	Stationary Machinery
Capital Cost ('000)	€42 – 252
Annual Maintenance ('000)	€1
Annual Testing ('000)	€1-5
Filters changes every 5 years ('000)	€5
Total annualised cost* ('000)	€5.7 - 25

Notes:
1) It is assumed that ventilation equipment last for 20 years and filters last 5 years. Costs are based on a 4% discount rate as recommended by the EC IA guidelines (2009)
2) The increased cost of a specialised solvent recovery systems is estimated as a 5% increase in capital cost compared to a standard LEV system.
3) The ventilation requirements of each plant location and operation will differ, therefore the costs in this table should be considered as indicative.

Appropriate respiratory equipment (RPE) and personal protective equipment (PPE) also has an impact on the magnitude of worker exposure to o-toluidine. The costs associated with enclosure, personal protective equipment (PPE) and respiratory protective equipment (RPE), are expected to be relatively low and in any case are considered to be good practice. It is assumed that costs range between €500-€2,000/year per enterprise.

This cost data has been used alongside the indicative estimate of number of enterprises affected by the possible OEL to estimate total compliance costs. Insufficient information was available to determine more accurately which measures might be required to meet the OEL for each firm size or sector. Therefore the following assumptions have been used based on expert judgement and available information:

- 33% of affected firms only incur costs of RPE, PPE and employee training to comply with the proposed OEL.
- 33% of affected firms have ventilation but do not necessarily use and/or maintain their system properly and flow rates may be too low. Therefore costs to effectively maintain and use their LEVs and use of respiratory protection should be sufficient to comply with the OEL.
- 33% of affected firms will incur costs associated with purchase, maintenance and use of LEV and use of RPE.

These estimates are subject to high uncertainty. Furthermore, these are assumed average and are applied to a small number of affected enterprises. They should therefore be seen as indicative rather than predictive. The estimated costs of compliance with an EU-wide OEL are summarised below in Table 4.7.

Table 4.7 Costs of compliance for control of EDB with proposed EU-wide OEL of 0.1pppm

Number of enterprises affected	Action required	Average annualised cost per enterprise (2010)		Total annual cost in millions (2010)	
		Low	High		
3	RPE [(1)]	€ 500	€ 2,000	€ 0.00	€ 0.01
3	RPE + proper use of existing LEV [(2)]	€ 3,123	€ 7,123	€ 0.01	€ 0.02
3	RPE, install and use new LEV	€ 6,214	€ 25,666	€ 0.02	€ 0.07
Total	-	-		€ 0.03	€ 0.09

(1) RPE = respiratory protective equipment
(2) LEV = local exhaust ventilation

As shown in Table 4.7 the annualised cost per firm is estimated to be between €0.5k and €26k. The number of firms affected is likely to be small and therefore the total cost of compliance in present value terms (i.e. in today's prices) is estimated to be a few tens to hundreds of thousands of Euros over the assessment period 2010-2069 for an OEL of 0.1ppm.

As described above, it is assumed that exposure will continue to decline. Therefore, it is likely that these risk management measures (RMMs) would occur at some point under the baseline and therefore the impact of introducing an EU-wide OEL of 0.1ppm is that reductions in exposure will be achieved sooner than would otherwise have occurred.

Conduct of employers

The introduction of an EU-wide OEL of 0.1ppm may require certain companies to reorganise their workplace to ensure that exposure to o-toluidine emissions is minimised. There may also be additional training and authorisation of personnel handling the substance required to ensure that employees minimise their exposure by adhering to good practice in order to reduce exposure (e.g. wearing protective clothing and ensuring process enclosure). However, in practice, it is expected that these activities are already taking place and thus there may well be no additional change beyond the baseline.

Potential of closure for companies

There is not expected to be any significant and additional potential for closure of companies as a result of introducing an EU-wide OEL of 0.1ppm because compliance costs are likely to be minimal.

Potential impacts for specific types of companies

There are not expected to be any particular impacts for specific types of companies, since any additional costs of meeting an OEL of 0.1ppm relative to the baseline scenario are likely to be minimal.

Any companies that require new ventilation systems would be affected more than those that do not.

Administrative costs to employers and public authorities

The following table (Table 4.8) describes the administrative burden to employers already subject to the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.8 Administrative burdens to employers

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Change in practice to use closed systems when using the substance.	5 – Prevention and reduction of exposure	These costs are already estimated in the cost of compliance section - This will only affect those firms that do not have or use closed systems	Estimated elsewhere
2. Develop/update health and safety and best practice guidance for: o Minimising use and exposure to workers to the substance o Redesign work processes and engineering controls to avoid/minimise release of carcinogens or mutagens o Hygiene measures, in particular regular cleaning of floors, walls and other surfaces o Information for workers o Warnings and safety signs o Drawing up plans to deal with emergencies likely to result in abnormally high exposure	5 – Prevention and reduction of exposure 7 – Unforeseen exposure 8 – Foreseeable exposure 9 – Access to risk areas 10 – Hygiene and individual protection	Firms will already have been required to develop/update health and safety and best practice guidance. The guidance and procedures may be required to be updated as control measures may change in light of a more stringent OEL. Some firms may need to redesign work practices to minimise exposure to workers and the number of workers exposed. The costs of implementing controls on exposure (such as LEV or PPE) are already estimated in the costs of compliance section.	Low
3. Additional costs of training new and existing staff in line with requirements of the Directive 4. Additional costs of making information available to employees 5. Consultation with employees on compliance with the Directive	11 – Information and training of workers 12 – Information for workers 13 – Consultation and participation with workers	Firms will already have been required to ensure training and adequate aware of risks and control measures to reduce/minimise exposure. Largely one-off cost if the revised OEL requires a change in control measures/working practice.	Low

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

The following table (Table 4.9) describes the administrative burden to competent authorities already enforcing the Carcinogens Directive but will now incur costs of introducing an EU wide OEL on to Annex III.

Table 4.9 Administrative burdens to Competent Authorities

Type of administrative cost	Relevant article(s)	Type of cost	Significance
1. Communication with the Commission on provisions in national law to enforce the revised OEL. 2. Time and costs of implementing revised OEL into national law (consultation process)	19 – Notifying the commission 20 – Repeal	Largely one-off cost of transposing the revised OEL into national law	Low - Medium (one-off cost)

Note: Readers should consult the Directive for the official wording around specific requirements. This table provides only a summary of what are perceived to be the most significant administrative requirements of the Directive. Grading of the significance of impacts is subjective and is based on professional judgement.

Third countries

Since it is not expected that the introduction of an EU-wide OEL will have significant impacts, there is not expected to be any significant impact on third countries such as redistribution of investment, jobs or sales.

As shown in Table 1.1, some non-EU countries have a pre-existing OEL in place. A harmonised EU-wide OEL may encourage other countries outside the EU to implement an OEL into national legislation.

4.2.2 Impact on innovation and research

Impacts on innovation and research from introducing an EU-wide OEL of 0.1ppm are expected to be minimal.

4.2.3 Macroeconomic impact

Short-term spending on risk management measures (RMMs) may be good for the economy as equipment manufacturers (ventilation systems), installers and other will benefit with money flowing through the economy, if the alternative is that profits are retained (by shareholders or the company and not spent e.g. on Research and Development, meaning the wider economy would not benefit from increased spending). However, since it is expected that these RMMs would occur under the baseline and overall costs/changes are expected to be small, there are not expected to be any macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.

4.3 SOCIAL IMPACTS

4.3.1 Employment and labour markets

There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL.

There are not expected to be any noticeable changes to jobs skills, patterns or the numbers of workers required as a result of using of ventilation systems. In terms of working conditions, the use of mechanical local ventilation may be better for workers than natural ventilation as air change rates and flow can be controlled, and thermal environmental conditions maintained at more acceptable levels. One of the disadvantages of using mechanical ventilation is heat loss, especially in colder regions. If the mechanical ventilation includes a heat exchanger with high efficiency, this might typically reduce the ventilation heat loss by 80-90% and the total heat loss by 30-60%, depending on the insulation level[28]. However, any such impact is likely to be small given the limited changes expected to be required to comply.

4.3.2 Changes in end products

There are not expected to be any noticeable changes to the end products since the likely control measures do not change the characteristics of the product. Since there is not expected to be any closure of companies, there should not be any change in supply of products relative to the baseline scenario.

4.4 ENVIRONMENTAL IMPACTS

o-Toluidine is classified in relation to its ecotoxic effects as R50 or category 1 H400 (very toxic to aquatic life).

The achievement of the possible OEL via the measures described in this report might lead to more direct or more concentrated emissions of o-toluidine to the environment (through ventilation), but it is unlikely that this would lead to an increased overall environmental burden. Furthermore the quantities and concentrations involved are relatively low. Therefore it is assumed that an OEL would not increase the level of environmental harm.

5 COMPARISON OF OPTIONS

The main impacts discussed in more detail in section 4 are summarised in the tables below, which are broken down by the main types of impacts (health, economic, social, macroeconomic and environmental).

[28] "Mechanical ventilation with heat recovery in cold climates" - http://web.byv.kth.se/bphys/reykjavik/pdf/art_157.pdf. (Note that this is in relation to housing rather than industrial buildings.)

Table 5.1 Comparison of health impacts by scenario (Present Value – 2010 €m prices)

<table>
<tr><th colspan="2">Baseline Scenario</th><th colspan="2">Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm</th><th colspan="2">Intervention scenario (3) – Assumes full compliance for OEL = 1ppm</th></tr>
<tr><th>Health Costs</th><th>Health Benefits</th><th>Health Costs</th><th>Health Benefits</th><th>Health Costs</th><th>Health Benefits</th></tr>
<tr>
<td>As set out in section 2.5, the health costs of cancer (bladder) over the period 2010-70 are estimated to be:
1) Females: €16m to €107m
2) Males: €70m to €590m
3) Total: €86m to €696m
This range takes into consideration tangible costs (e.g. lost income, lost output from reduced productivity, medical costs, life years lost) and intangible costs (e.g. emotional and physical suffering from having cancer).</td>
<td>It is assumed that exposures will fall by 8.8% per year in the future.
Therefore there is expected to be some reduction in health costs going forward in the absence of further regulatory intervention</td>
<td>There is expected to be a small cost saving (e.g. a few €k) from avoided health care and reduced cost of illness due to reductions in cancer registrations.
This has been estimated as a benefit.</td>
<td>Health benefits of the possible OEL have been analysed at the Member State and industrial sector level. The results showed that the benefits of introducing an OEL in 2010 are most apparent to the manufacture of chemical products and manufacture of rubber products sector. It was also found that the monetised benefits are likely to affect men more than women.
The monetised benefits over 2010-2070 were estimated as:
Females: €0.2m to 1.2m
Males: €0.8m to 6.5m
Totals: €1m to 7.6m</td>
<td>No change - There are not expected to be any additional health costs relative to the baseline scenarios.</td>
<td>No change – There are expected to be negligible additional health benefits relative to the baseline scenario, as exposure is already expected to be largely/wholly below 1ppm.</td>
</tr>
</table>

Table 5.2 Comparison of economic impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm		Intervention scenario (3) – Assumes full compliance for OEL = 1ppm	
Economic Costs	**Economic Benefits**	**Economic Costs**	**Economic Benefits**	**Economic Costs**	**Economic Benefits**
There are expected to be costs to o-toluidine related firms to put into place improved training and cleaning measures to reduce inhalation and dermal exposure that would occur regardless of further intervention over the period 2010-2070.	-	There are expected to be economic costs related to changes to workplace practices in order to meet the possible OEL for the manufacture of chemical products and manufacture of rubber products industries. It is estimated that few (less than 10) enterprises would require some form of additional control measure to meet the possible OEL (the calculated value was eight enterprises). The remainder are assumed to already be meeting the possible OEL under the baseline scenario and therefore would require no further action. It is assumed that the majority of those enterprises that do not currently comply would need to implement relatively low-cost measures to reduce exposure levels to meet this OEL. These costs (€0.5-2k) are not considered to be significant. The remainder may need to invest in new ventilation systems. The up-front capital cost of a ventilation system is estimated to be in the region of €42k - 252k. There would be administrative costs of implementing the OEL in national legislation and of demonstrating and verifying compliance.	Having an EU-wide BMGV should remove any EU competitive distortions between EU Member States with different limits.	**Minimal** - The vast majority of investment required to control exposure associated with the manufacture of o-toluidine has already occurred in the last 20 years.	Having an EU-wide OEL should remove any EU competitive distortions between EU Member States with different limits.

Table 5.3 Comparison of social impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm		Intervention scenario (3) – Assumes full compliance for OEL = 1ppm	
Social Costs	Social Benefits	Social Costs	Social Benefits	Social Costs	Social Benefits
There are not expected to be any noticeable social impacts under the baseline scenario at an EU level.		**No change -** There are not expected to be any noticeable changes to the numbers of workers required as a result of introducing an EU-wide OEL.			

Table 5.4 Comparison of macro-economic impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm		Intervention scenario (3) – Assumes full compliance for OEL = 1ppm	
Macro-economic Costs	Macro-economic Benefits	Macro-economic Costs	Macro-economic Benefits	Macro-economic Costs	Macro-economic Benefits
There are not expected to be any noticeable macroeconomic impacts under the baseline scenario.		There are not expected to be any significant macroeconomic impacts relative to the baseline scenario from introducing an EU-wide OEL.			

Table 5.5 Comparison of environmental impacts by scenario (Present Value – 2010 €m prices)

Baseline Scenario		Intervention scenario (2) – Assumes full compliance for OEL = 0.1ppm		Intervention scenario (3) – Assumes full compliance for OEL = 1ppm	
Environmental Costs	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**	**Environmental Costs**	**Environmental Benefits**
Only 2% of workers exposed to o-toluidine are estimated to be exposed above 0.1ppm and therefore most workplaces are unlikely to be affected/require further changes to their existing working practices. Therefore there are not estimated to be any significant changes in environmental impacts.		Minimal – it is expected that the imposition of measures would not cause significant additional environmental impacts.	It is not expected that the measures for human health would lead to any significant additional environmental benefit above the baseline.	None - it is assumed that controls on o-toluidine in the workplace that would be needed to meet this OEL have already been implemented. Therefore it is not expected that achievement of the OEL would lead to changes in environmental impacts.	

Note: Costs and benefits under the intervention options are relative to the baseline scenario (i.e. are not absolute impacts but differences)

6 CONCLUSIONS

Exposure to o-toluidine may cause bladder cancer. The International Agency for Research on Cancer considers this substances is a possible human carcinogen (category 2b) and it is classified as a category 2 carcinogen in Europe under the classification and labelling regulations. Workers may be exposed by inhalation exposure and from skin contact. This report considers the likely health, socioeconomic and environmental impacts associated with possible changes to the EU Carcinogens Directive, in particular the possible introduction of an occupational exposure limit (OEL) of either 0.1 ppm or 1ppm. Because of the potential for uptake of o-toluidine though the skin we assume the limit would be associated with a “skin notation”, which would imply additional precautions for dermal exposure.

Bladder cancer is a relatively common cancer that is generally diagnosed on people over 60 years of age. There are about twice as many cases diagnosed on men compared to women. In the EU it comprises about 5% of all cancer incidences. About half of all people diagnosed with this cancer will die from their disease.

Ortho-toluidine is a synthetic aromatic amine, which is used primarily as feedstock in chemical synthesis. In the past its major use was in the production of dyes but in Europe this use has decreased as a consequence of legislative restrictions. Between 3,000 and 14,000 tonnes of o-toluidine are currently produced in Western Europe each year. About 5,500 workers are probably exposed in the EU. It is judged that 98% of workers in the relevant industries were currently exposed below 0.1 ppm and that over recent year’s exposure levels have been decreasing by about 8.8% per annum.

The predicted number of deaths from past occupational exposure to o-toluidine is low (in 2010, 7 deaths and 120 Disability-Adjusted Life Years) and that this will decrease steadily in the future so that by 2050 there are no predicted deaths occurring. Introducing a OEL of either 0.1 or 1 ppm has no important effect on the predicted cancer deaths or registrations from o-toluidine exposure at work.

If there was no limit value introduced the health costs over the next 60 years are estimated to be between €86m and €696m. There are no health benefits from introducing a limit at 1 ppm and between €1m and €7.6m for the 0.1 ppm limit. Corresponding cost of compliance over the same period are estimated as between €0.03m and €0.09m.

It are not expected that there will be any important social, macro-economic or environmental impacts.

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8 APPENDIX

8.1 ESTIMATED NUMBER OF WORKERS EXPOSED TO O-TOLUIDINE IN THE EU – MALES AND FEMALES

Table 8.1.1

NACE code Rev1	24			25.1			73			75			80			85			Grand Total		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Austria	40	33	8	2	2	0	2	1	1	8	5	3	19	6	14	10	2	7	**81**	**48**	**33**
Belgium	105	85	20	2	2	0	2	1	1	13	8	5	33	10	23	14	3	10	**169**	**110**	**59**
Bulgaria	39	20	19	3	1	1	0	0	0	7	5	2	19	6	13	5	1	3	**72**	**34**	**38**
Cyprus	3	2	1	0	0	0	0	0	0	1	1	0	2	1	1	0	0	0	**6**	**3**	**3**
Czech Republic	62	40	22	15	10	5	2	1	1	10	5	5	25	6	19	9	2	7	**123**	**64**	**58**
Denmark	45	33	12	1	1	0	2	1	1	5	3	2	19	8	11	14	3	12	**86**	**48**	**38**
Estonia	4	2	2	0	0	0	0	0	0	1	0	1	5	1	4	1	0	1	**12**	**4**	**8**
Finland	27	20	7	2	2	1	1	1	0	3	2	2	15	5	10	11	1	10	**59**	**30**	**29**
France	413	318	95	46	35	10	13	8	5	72	36	36	158	51	107	83	22	61	**785**	**471**	**315**
Germany	687	392	295	50	29	22	30	11	20	86	25	61	185	39	146	114	16	98	**1153**	**511**	**642**
Greece	27	21	7	1	0	0	3	2	1	11	8	4	27	10	17	6	2	4	**75**	**43**	**32**
Hungary	48	30	18	7	4	3	2	1	1	9	4	4	28	7	21	8	2	6	**102**	**49**	**53**
Ireland	37	28	9	0	0	0	1	1	0	3	2	1	12	3	8	6	1	5	**59**	**35**	**24**
Italy	300	225	75	31	23	8	8	5	3	43	29	14	136	33	104	40	13	27	**559**	**328**	**231**
Latvia	7	4	3	0	0	0	0	0	0	3	1	1	8	1	6	1	0	1	**19**	**7**	**12**
Lithuania	9	5	4	0	0	0	0	0	0	2	1	1	12	2	10	3	0	3	**27**	**9**	**18**
Luxembourg	2	1	0	3	2	0		Not Available		1	1	0	1	0	1	1	0	0	**7**	**5**	**2**
Malta		Not Available		0	0	0		Not Available		0	0	0	1	0	1	0	0	0	**2**	**1**	**1**
Netherlands	96	78	17	2	2	0	11	7	4	17	10	7	48	20	28	36	8	28	**209**	**125**	**84**
Poland	162	109	53	22	15	7	1	1	0	28	15	13	101	24	77	24	5	19	**338**	**168**	**170**
Portugal	32	19	13	4	2	1	0	0	0	11	7	4	28	7	20	9	2	8	**84**	**37**	**47**
Romania	73	40	34	9	5	4	7	5	3	15	9	6	37	10	27	11	3	8	**152**	**70**	**81**
Slovakia	19	12	7	4	3	2	1	1	1	5	2	2	15	3	12	4	1	4	**49**	**22**	**27**
Slovenia	21	14	7	2	2	1	1	1	0	2	1	1	7	1	5	2	0	1	**34**	**19**	**16**
Spain	209	163	46	20	16	4	5	3	3	37	21	16	95	35	60	33	10	23	**399**	**247**	**152**

	NACE code Rev1 24			25.1			73			75			80			85			Grand Total		
	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females
Sweden	65	51	14	4	3	1	4	2	1	8	4	4	43	11	32	21	4	17	**145**	**75**	**70**
United Kingdom	322	261	61	19	15	4	33	22	11	61	34	28	226	81	144	99	27	72	**760**	**440**	**320**
TOTAL	2855	2005	849	250	174	76	131	76	56	460	238	222	1305	382	923	564	128	436	**5565**	**3002**	**2562**

8.2 ESTIMATED DEATHS AND REGISTRATIONS IN THE EU FROM BLADDER CANCER

Table 8.2.1 Forecast number of bladder cancers in ages 25+ (ages 15+ for registrations), based on projected EU country populations

Bladder cancer deaths	*MEN*						*WOMEN*					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Austria	372	488	623	791	957	951	172	189	230	280	334	331
Belgium	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	387	404	445	490	531	548	119	125	136	142	147	149
Cyprus	32	44	59	77	96	115	3	5	7	9	12	15
Czech Republic	586	762	1,011	1,166	1,353	1,569	233	274	329	359	390	420
Denmark	408	536	672	754	810	811	175	210	252	279	295	294
Estonia	64	73	87	106	124	146	31	35	37	42	45	46
Finland	185	245	322	353	359	376	71	86	107	121	123	121
France	3,879	4,718	5,888	6,875	7,459	7,820	1,230	1,400	1,675	2,007	2,167	2,193
Germany (including ex-GDR from 1991)	4,075	5,444	6,257	7,520	8,350	7,819	2,005	2,360	2,572	2,989	3,319	3,069
Greece	921	1,098	1,264	1,532	1,792	1,942	200	256	283	334	385	410
Hungary	568	652	766	897	1,013	1,145	240	268	300	332	345	375
Ireland	138	192	267	354	458	569	67	84	113	149	188	234
Italy	4,620	5,650	6,689	7,945	9,277	9,511	1,257	1,474	1,668	1,918	2,236	2,314
Latvia	126	138	157	185	210	234	57	62	65	72	77	83
Lithuania	194	223	266	332	393	436	56	63	69	82	89	91
Luxembourg	22	30	40	54	64	70	8	9	10	14	17	19
Malta	34	47	68	81	86	101	8	11	15	17	18	20
Netherlands	900	1,196	1,600	1,869	2,025	1,974	367	441	555	646	690	673
Poland	2,446	3,056	3,942	4,731	5,213	5,936	649	768	928	1,113	1,141	1,238
Portugal	560	674	808	981	1,149	1,279	207	253	295	351	406	445
Romania	1,011	1,131	1,330	1,577	1,810	1,931	307	340	397	451	510	551

Bladder cancer deaths	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Slovakia	199	253	350	446	523	614	75	90	116	139	153	172
Slovenia	101	136	175	215	235	246	45	53	62	73	77	78
Spain	4,148	5,075	6,370	8,147	9,959	10,917	870	1,033	1,238	1,545	1,886	2,106
Sweden	491	608	759	837	924	987	181	205	250	276	299	317
United Kingdom	3,481	4,249	5,260	6,126	7,001	7,473	1,691	1,873	2,260	2,638	3,019	3,190
European Union (27 countries)	30,722	37,976	46,330	55,274	62,497	65,778	10,637	12,330	14,440	16,995	18,957	19,638

Bladder cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Austria	1,715	2,072	2,518	2,815	2,916	2,960	559	625	732	810	835	834
Belgium	2,030	2,449	2,895	3,176	3,304	3,430	548	627	724	793	823	842
Bulgaria	636	656	695	736	753	730	171	177	183	186	183	175
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	1,759	2,186	2,488	2,787	3,040	3,050	636	736	809	873	918	915
Denmark	784	971	1,101	1,174	1,168	1,207	255	300	338	360	362	368
Estonia	156	170	191	213	236	248	55	59	62	64	66	67
Finland	686	882	983	1,001	1,019	1,048	220	266	293	299	297	298
France	10,183	12,430	14,253	15,519	16,066	16,701	2,158	2,575	2,959	3,250	3,310	3,336
Germany (including ex-GDR from 1991)	22,629	26,022	29,785	31,514	30,871	29,765	7,445	8,054	8,924	9,346	9,152	8,754
Greece	2,311	2,632	3,018	3,441	3,670	3,591	467	529	590	658	693	673
Hungary	1,456	1,630	1,809	2,016	2,201	2,256	540	582	613	640	662	661
Ireland	476	636	814	1,006	1,199	1,290	171	223	285	348	411	445
Italy	18,441	21,391	24,656	27,696	28,472	27,931	3,718	4,172	4,682	5,204	5,339	5,171
Latvia	205	217	243	270	293	304	72	73	78	81	83	84
Lithuania	351	382	450	510	552	583	105	111	124	133	136	136
Luxembourg	118	156	202	240	261	281	35	42	51	59	65	69
Malta	61	81	94	100	110	116	18	23	26	27	28	30
Netherlands	4,771	6,115	7,167	7,614	7,495	7,568	1,111	1,340	1,545	1,643	1,631	1,618
Poland	6,023	7,376	8,506	9,448	10,301	10,435	1,303	1,524	1,731	1,834	1,919	1,925
Portugal	1,695	1,958	2,269	2,570	2,754	2,790	467	532	601	666	699	695
Romania	2,508	2,757	3,134	3,579	3,840	3,818	678	738	809	890	929	916
Slovakia	522	675	833	961	1,088	1,120	165	201	240	265	287	294
Slovenia	182	233	281	309	324	313	50	57	65	70	72	69
Spain	12,477	15,309	18,883	22,192	23,633	23,079	1,710	2,022	2,425	2,846	3,090	3,035

Bladder cancer registrations	MEN						WOMEN					
FTY	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
Sweden	1,792	2,133	2,376	2,559	2,687	2,868	593	672	742	797	828	871
United Kingdom	9,713	11,527	13,260	14,634	15,638	17,095	3,654	4,144	4,754	5,296	5,627	6,031
European Union (27 countries)	102,412	121,289	140,370	155,410	162,871	164,733	26,842	30,599	34,652	37,902	39,265	39,223

8.3 SUPPLEMENTARY TABLES - COSTS UNDER THE BASELINE SCENARIO

Table 8.3.1 Health costs – baseline scenario – Member State breakdown - Based on a 4% discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0	€ 1	€ 1	Austria	€ 1	€ 8	€ 9
Belgium	€ 0	€ 1	€ 1	Belgium	€ 2	€ 22	€ 24
Bulgaria	€ 0	€ 0	€ 1	Bulgaria	€ 1	€ 2	€ 3
Czech Republic	€ 0	€ 1	€ 2	Czech Republic	€ 3	€ 11	€ 14
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 0	€ 1	€ 1	Denmark	€ 1	€ 6	€ 7
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 0	€ 1
Finland	€ 0	€ 0	€ 0	Finland	€ 1	€ 3	€ 4
France	€ 2	€ 15	€ 17	France	€ 9	€ 95	€ 104
Germany	€ 6	€ 13	€ 19	Germany	€ 53	€ 144	€ 197
Greece	€ 0	€ 1	€ 1	Greece	€ 0	€ 4	€ 5
Hungary	€ 0	€ 1	€ 1	Hungary	€ 2	€ 6	€ 8
Ireland	€ 0	€ 0	€ 1	Ireland	€ 1	€ 4	€ 5
Italy	€ 1	€ 10	€ 11	Italy	€ 9	€ 91	€ 100
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 0	€ 1
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 1	€ 1
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 1	€ 1
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 2	€ 3	Netherlands	€ 2	€ 28	€ 30
Poland	€ 1	€ 4	€ 5	Poland	€ 4	€ 25	€ 29
Portugal	€ 0	€ 0	€ 1	Portugal	€ 1	€ 4	€ 5
Romania	€ 0	€ 1	€ 1	Romania	€ 2	€ 6	€ 9
Slovakia	€ 0	€ 0	€ 0	Slovakia	€ 0	€ 2	€ 2
Slovenia	€ 0	€ 0	€ 1	Slovenia	€ 0	€ 2	€ 2
Spain	€ 0	€ 4	€ 5	Spain	€ 2	€ 30	€ 32
Sweden	€ 0	€ 1	€ 2	Sweden	€ 2	€ 12	€ 14
United Kingdom	€ 2	€ 11	€ 13	United Kingdom	€ 10	€ 80	€ 90
TOTAL	€ 16	€ 70	€ 86	**TOTAL**	€ 107	€ 590	€ 696

Table 8.3.2 Health costs - baseline scenario - Industry group breakdown - Based on a 4% discount rate

Low	Female	Male	Total
Manufacture of chemicals, chemical products and man-made fibres	€ 14	€ 68	€ 82
Manufacture of Rubber Products	€ 1	€ 6	€ 7
TOTAL	€ 16	€ 74	€ 89

High	Female	Male	Total
Manufacture of chemicals, chemical products and man-made fibres	€ 87	€ 544	€ 631
Manufacture of Rubber Products	€ 8	€ 47	€ 54
TOTAL	€ 95	€ 591	€ 686

Table 8.3.3 Health costs – baseline scenario – Member State breakdown - Based on a declining discount rate

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0	€ 1	€ 1	Austria	€ 1	€ 9	€ 10
Belgium	€ 0	€ 1	€ 1	Belgium	€ 2	€ 23	€ 25
Bulgaria	€ 0	€ 0	€ 1	Bulgaria	€ 1	€ 2	€ 3
Czech Republic	€ 1	€ 1	€ 2	Czech Republic	€ 3	€ 12	€ 15
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 0	€ 1	€ 1	Denmark	€ 1	€ 6	€ 7
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 0	€ 1
Finland	€ 0	€ 0	€ 0	Finland	€ 1	€ 4	€ 4
France	€ 2	€ 16	€ 18	France	€ 9	€ 99	€ 108
Germany	€ 7	€ 13	€ 20	Germany	€ 56	€ 153	€ 209
Greece	€ 0	€ 1	€ 1	Greece	€ 0	€ 5	€ 5
Hungary	€ 0	€ 1	€ 1	Hungary	€ 2	€ 7	€ 8
Ireland	€ 0	€ 1	€ 1	Ireland	€ 1	€ 4	€ 5
Italy	€ 1	€ 10	€ 12	Italy	€ 9	€ 96	€ 106
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 0	€ 1
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 1	€ 1
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 1	€ 1
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 0	€ 3	€ 3	Netherlands	€ 2	€ 29	€ 32
Poland	€ 1	€ 4	€ 5	Poland	€ 4	€ 27	€ 31
Portugal	€ 0	€ 1	€ 1	Portugal	€ 1	€ 4	€ 5
Romania	€ 0	€ 1	€ 1	Romania	€ 2	€ 7	€ 9
Slovakia	€ 0	€ 0	€ 0	Slovakia	€ 0	€ 2	€ 2
Slovenia	€ 0	€ 0	€ 1	Slovenia	€ 0	€ 2	€ 2
Spain	€ 0	€ 5	€ 5	Spain	€ 2	€ 32	€ 34
Sweden	€ 0	€ 1	€ 2	Sweden	€ 2	€ 13	€ 14
United Kingdom	€ 2	€ 11	€ 13	United Kingdom	€ 11	€ 82	€ 93
TOTAL	€ 17	€ 73	€ 90	**TOTAL**	€ 112	€ 620	€ 732

Table 8.3.4 Health costs – baseline scenario – Industry group breakdown - Based on a declining discount rate

Low	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 15	€ 71	€ 86
Manufacture of chemicals and chemical products	€ 1	€ 6	€ 7
TOTAL	€ 16	€ 77	€ 94

High	Female	Male	Total
Manufacture of coke, refined petroleum products and nuclear fuel	€ 92	€ 571	€ 662
Manufacture of chemicals and chemical products	€ 8	€ 49	€ 57
TOTAL	€ 100	€ 620	€ 719

Table 8.3.5 Summary of health costs

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	8 to 56	5 to 34	2 to 16	1 to 4	0 to 1	0 to 1
Male	36 to 308	22 to 190	10 to 87	3 to 22	1 to 7	1 to 6
Total	45 to 364	28 to 223	13 to 103	3 to 26	1 to 8	1 to 7

Table 8.3.6 Health costs – baseline scenario – Member State breakdown - Based on a no discounting approach

Low	Female	Male	Total	High	Female	Male	Total
Austria	€ 0	€ 1	€ 2	Austria	€ 2	€ 14	€ 16
Belgium	€ 0	€ 1	€ 1	Belgium	€ 4	€ 38	€ 42
Bulgaria	€ 0	€ 1	€ 1	Bulgaria	€ 1	€ 4	€ 5
Czech Republic	€ 1	€ 2	€ 3	Czech Republic	€ 6	€ 20	€ 25
Cyprus	€ 0	€ 0	€ 0	Cyprus	€ 0	€ 0	€ 0
Denmark	€ 1	€ 2	€ 2	Denmark	€ 2	€ 10	€ 12
Estonia	€ 0	€ 0	€ 0	Estonia	€ 0	€ 1	€ 1
Finland	€ 0	€ 1	€ 1	Finland	€ 1	€ 6	€ 7
France	€ 4	€ 26	€ 29	France	€ 15	€ 160	€ 174
Germany	€ 11	€ 23	€ 34	Germany	€ 93	€ 258	€ 351
Greece	€ 0	€ 1	€ 1	Greece	€ 1	€ 7	€ 8
Hungary	€ 1	€ 2	€ 2	Hungary	€ 3	€ 11	€ 14
Ireland	€ 0	€ 1	€ 1	Ireland	€ 1	€ 7	€ 9
Italy	€ 2	€ 17	€ 19	Italy	€ 16	€ 159	€ 175
Latvia	€ 0	€ 0	€ 0	Latvia	€ 0	€ 1	€ 1
Lithuania	€ 0	€ 0	€ 0	Lithuania	€ 0	€ 1	€ 1
Luxembourg	€ 0	€ 0	€ 0	Luxembourg	€ 0	€ 2	€ 2
Malta	€ 0	€ 0	€ 0	Malta	€ 0	€ 0	€ 0
Netherlands	€ 1	€ 4	€ 5	Netherlands	€ 4	€ 47	€ 51
Poland	€ 1	€ 7	€ 8	Poland	€ 7	€ 44	€ 50
Portugal	€ 0	€ 1	€ 1	Portugal	€ 2	€ 6	€ 8
Romania	€ 1	€ 2	€ 2	Romania	€ 4	€ 11	€ 15
Slovakia	€ 0	€ 0	€ 1	Slovakia	€ 1	€ 3	€ 4
Slovenia	€ 0	€ 1	€ 1	Slovenia	€ 1	€ 4	€ 4
Spain	€ 1	€ 8	€ 9	Spain	€ 3	€ 58	€ 61
Sweden	€ 0	€ 2	€ 3	Sweden	€ 3	€ 20	€ 23
United Kingdom	€ 3	€ 18	€ 21	United Kingdom	€ 17	€ 126	€ 143
TOTAL	€ 28	€ 120	€ 148	**TOTAL**	€ 184	€ 1,017	€ 1,201

Table 8.3.7 Health costs – baseline scenario – Industry group breakdown - Based on a no discounting approach

Low	Female	Male	Total
	€ 25	€ 117	€ 142
	€ 2	€ 10	€ 12
TOTAL	€ 27	€ 127	€ 154

High	Female	Male	Total
Fishing, fish farming and related service activities	€ 150	€ 932	€ 1,082
Mining of coal and lignite; extraction of peat	€ 13	€ 80	€ 94
TOTAL	€ 163	€ 1,012	€ 1,176

Table 8.3.8 Summary of health costs

Costs by Gender (€m)	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
Female	10 to 68	9 to 61	5 to 33	2 to 11	1 to 5	1 to 6
Male	44 to 375	40 to 341	21 to 183	7 to 61	3 to 25	4 to 32
Total	55 to 443	50 to 402	26 to 216	9 to 73	4 to 30	5 to 38

8.4 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

Table 8.4.1 Proportions exposed above the exposure limits being tested by country, forecast scenario

Forecast Scenario	**1971-80**	**1981-90**	**1991-00**	**2001-10**	**2011-20**	**2021-30**	**1971-80**	**1981-90**	**1991-00**	**2001-10**	**2011-20**	**2021-30**
OEL	***0.1 ppm***						***1 ppm***					
Austria	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Belgium	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Bulgaria	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Cyprus	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Czech Republic	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Denmark	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Estonia	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Finland	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
France	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Germany	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Greece	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Hungary	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Ireland	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Italy	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Latvia	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Lithuania	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Luxembourg	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Malta	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Netherlands	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Poland	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00

Forecast Scenario	**1971-80**	**1981-90**	**1991-00**	**2001-10**	**2011-20**	**2021-30**	**1971-80**	**1981-90**	**1991-00**	**2001-10**	**2011-20**	**2021-30**
OEL	***0.1 ppm***						***1 ppm***					
Portugal	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Romania	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Slovakia	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Slovenia	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Spain	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
Sweden	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
United Kingdom	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.00	0.00	0.00
TOTAL	0.80	0.50	0.20	0.05	0.05	0.05	0.10	0.02	0.00	0.000	0.00	0.00

Table 8.4.2 Numbers and proportions of the population ever exposed for baseline and intervention[1] scenarios (2) to (3), by country, men plus women

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Number ever exposed in the REP														
Austria	285	315	345	366	378	378	345	366	378	378	336	349	351	342
Belgium	604	655	708	742	761	761	708	742	761	761	682	689	681	720
Bulgaria	279	303	329	346	355	355	329	346	355	355	324	335	339	334
Cyprus	22	24	26	28	29	29	26	28	29	29	26	27	28	27
Czech Republic	465	504	544	570	584	584	544	570	584	584	528	538	537	557
Denmark	310	341	373	395	407	407	373	395	407	407	364	378	381	372
Estonia	47	53	59	63	65	65	59	63	65	65	58	62	64	63
Finland	213	236	260	278	287	287	260	278	287	287	255	267	270	264
France	3,201	3,329	3,452	3,590	3,635	3,635	3,452	3,590	3,635	3,635	3,352	3,391	3,338	3,231
Germany	4,551	4,916	5,299	5,541	5,671	5,671	5,299	5,541	5,671	5,671	5,146	5,234	5,210	5,604
Greece	256	288	322	347	360	360	322	347	360	360	318	340	350	346
Hungary	381	418	457	483	497	497	457	483	497	497	447	464	469	459
Ireland	216	234	253	265	271	271	253	265	271	271	244	246	244	261
Italy	2,032	2,215	2,406	2,533	2,601	2,601	2,406	2,533	2,601	2,601	2,335	2,390	2,387	2,311
Latvia	70	79	88	95	99	99	88	95	99	99	88	94	97	96
Lithuania	100	113	126	136	142	142	126	136	142	142	125	134	139	138
Luxembourg	23	25	28	29	30	30	28	29	30	30	27	27	27	27
Malta	6	7	8	9	10	10	8	9	10	10	8	9	10	10
Netherlands	724	806	890	951	984	984	890	951	984	984	873	916	931	912

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Number ever exposed in the REP														
Poland	1,258	1,381	1,508	1,596	1,643	1,643	1,508	1,596	1,643	1,643	1,473	1,526	1,538	1,501
Portugal	309	345	382	409	423	423	382	409	423	423	377	400	410	405
Romania	579	634	691	729	750	750	691	729	750	750	680	708	719	708
Slovakia	182	202	222	237	244	244	222	237	244	244	218	229	233	229
Slovenia	131	141	151	157	161	161	151	157	161	161	146	146	155	176
Spain	1,051	1,296	1,547	1,734	1,835	1,835	1,547	1,734	1,835	1,835	1,500	1,640	1,694	1,644
Sweden	518	576	635	678	701	701	635	678	701	701	621	650	659	644
United Kingdom	3,243	3,354	3,466	3,558	3,607	3,607	3,466	3,558	3,607	3,607	3,407	3,440	3,429	3,366
TOTAL	21,058	22,789	24,577	25,866	26,529	26,529	24,577	25,866	26,529	26,529	23,959	24,631	24,678	24,017

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Proportion of the population exposed														
Austria	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.01%	0.00%
Belgium	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Bulgaria	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Cyprus	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Czech Republic	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Denmark	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Estonia	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Finland	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
France	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Germany	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Greece	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Hungary	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Ireland	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Italy	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
Latvia	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Lithuania	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Luxembourg	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Malta	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Netherlands	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Poland	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Portugal	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Proportion of the population exposed														
Romania	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.01%
Slovakia	0.00%	0.00%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Slovenia	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Spain	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sweden	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
United Kingdom	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
TOTAL	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%

Table 8.4.3 Results for baseline and intervention[1] scenarios for lung cancer, by county, men plus women

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Fraction														
Austria	0.013%	0.008%	0.003%	0.001%	0.000%	0.000%	0.003%	0.001%	0.000%	0.000%	0.003%	0.002%	0.003%	0.004%
Belgium	0.028%	0.018%	0.008%	0.002%	0.001%	0.001%	0.008%	0.002%	0.000%	0.000%	0.008%	0.004%	0.007%	0.011%
Bulgaria	0.012%	0.008%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%	0.004%	0.002%	0.004%	0.006%
Cyprus	0.010%	0.005%	0.002%	0.000%	0.000%	0.000%	0.002%	0.000%	0.000%	0.000%	0.002%	0.001%	0.001%	0.002%
Czech Republic	0.018%	0.012%	0.005%	0.001%	0.000%	0.001%	0.005%	0.001%	0.000%	0.000%	0.005%	0.003%	0.005%	0.008%
Denmark	0.021%	0.013%	0.005%	0.001%	0.000%	0.000%	0.005%	0.001%	0.000%	0.000%	0.005%	0.003%	0.005%	0.007%
Estonia	0.009%	0.005%	0.002%	0.000%	0.000%	0.000%	0.002%	0.000%	0.000%	0.000%	0.002%	0.001%	0.002%	0.003%
Finland	0.014%	0.009%	0.003%	0.001%	0.000%	0.000%	0.003%	0.001%	0.000%	0.000%	0.003%	0.002%	0.003%	0.005%
France	0.027%	0.016%	0.006%	0.001%	0.000%	0.000%	0.006%	0.001%	0.000%	0.000%	0.006%	0.003%	0.005%	0.007%
Germany	0.020%	0.014%	0.006%	0.002%	0.001%	0.001%	0.006%	0.002%	0.000%	0.000%	0.006%	0.004%	0.007%	0.010%
Greece	0.006%	0.004%	0.001%	0.000%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%	0.001%	0.001%	0.001%	0.002%
Hungary	0.013%	0.009%	0.003%	0.001%	0.000%	0.000%	0.003%	0.001%	0.000%	0.000%	0.003%	0.002%	0.003%	0.005%
Ireland	0.022%	0.013%	0.005%	0.001%	0.000%	0.000%	0.005%	0.001%	0.000%	0.000%	0.005%	0.003%	0.004%	0.007%
Italy	0.014%	0.009%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%	0.004%	0.002%	0.004%	0.006%
Latvia	0.007%	0.004%	0.001%	0.000%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%	0.001%	0.001%	0.001%	0.002%
Lithuania	0.007%	0.004%	0.001%	0.000%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%	0.001%	0.001%	0.001%	0.002%
Luxembourg	0.024%	0.015%	0.006%	0.001%	0.000%	0.000%	0.006%	0.001%	0.000%	0.000%	0.006%	0.003%	0.005%	0.007%
Malta	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
Netherlands	0.015%	0.010%	0.003%	0.001%	0.000%	0.000%	0.003%	0.001%	0.000%	0.000%	0.003%	0.002%	0.003%	0.005%
Poland	0.012%	0.008%	0.003%	0.001%	0.000%	0.000%	0.003%	0.001%	0.000%	0.000%	0.003%	0.002%	0.003%	0.005%

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Fraction														
Portugal	0.008%	0.005%	0.001%	0.000%	0.000%	0.000%	0.001%	0.000%	0.000%	0.000%	0.001%	0.001%	0.001%	0.002%
Romania	0.009%	0.006%	0.002%	0.001%	0.000%	0.000%	0.002%	0.000%	0.000%	0.000%	0.002%	0.001%	0.002%	0.004%
Slovakia	0.011%	0.006%	0.002%	0.000%	0.000%	0.000%	0.002%	0.000%	0.000%	0.000%	0.002%	0.001%	0.002%	0.004%
Slovenia	0.027%	0.019%	0.009%	0.003%	0.001%	0.001%	0.009%	0.002%	0.000%	0.000%	0.009%	0.005%	0.009%	0.015%
Spain	0.006%	0.004%	0.002%	0.001%	0.000%	0.000%	0.002%	0.001%	0.000%	0.000%	0.002%	0.002%	0.003%	0.005%
Sweden	0.019%	0.012%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%	0.004%	0.002%	0.004%	0.006%
United Kingdom	0.023%	0.013%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.002%	0.004%
TOTAL	0.017%	0.011%	0.004%	0.001%	0.000%	0.000%	0.004%	0.001%	0.000%	0.000%	0.004%	0.002%	0.004%	0.006%

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Deaths														
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Germany	1	1	1	0	0	0	1	0	0	0	1	0	1	1
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario / Country	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Deaths														
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	1	1	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7	5	2	1	0	0	2	1	0	0	2	2	3	5

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Registrations														
Austria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	3	3	1	0	0	0	1	0	0	0	1	1	1	1
Germany	6	5	2	1	0	0	2	1	0	0	2	1	3	4
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	3	2	1	0	0	0	1	0	0	0	1	1	1	2
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Poland	1	1	0	0	0	0	0	0	0	0	0	0	0	1

Scenario / Country	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Registrations														
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	3	2	1	0	0	0	1	0	0	0	1	0	1	1
TOTAL	22	16	7	2	1	1	7	2	0	0	7	4	8	12

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Years of Life Lost (YLLs)														
Austria	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	2	1	1	0	0	0	1	0	0	0	1	0	1	1
Denmark	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	17	12	5	1	0	0	5	1	0	0	5	3	5	8
Germany	14	12	6	2	1	1	6	2	0	0	6	4	7	11
Greece	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Ireland	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Italy	9	7	3	1	0	0	3	1	0	0	3	2	4	6
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	2	2	1	0	0	0	1	0	0	0	1	0	1	1
Poland	5	3	2	0	0	0	2	0	0	0	2	1	2	3

Scenario	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Country	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Years of Life Lost (YLLs)														
Portugal	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	4	3	2	1	0	0	2	1	0	0	2	2	4	6
Sweden	1	1	0	0	0	0	0	0	0	0	0	0	0	1
United Kingdom	13	9	3	1	0	0	3	1	0	0	3	1	2	4
TOTAL	81	60	26	7	3	3	26	7	1	0	26	16	31	49

Scenario / Country	All Scenarios 2010	All Scenarios 2020	Baseline scenario (1) - Current (2005) employment and exposure levels are maintained 2030	2040	2050	2060	Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm 2030	2040	2050	2060	Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm 2030	2040	2050	2060
Attributable Years of Life Lived with Disability (DALYs)														
Austria	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Belgium	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Bulgaria	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Republic	2	2	1	0	0	0	1	0	0	0	1	1	1	2
Denmark	2	1	1	0	0	0	1	0	0	0	1	0	1	1
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	1	0	0	0	0	0	0	0	0	0	0	0	0	0
France	21	15	6	2	0	1	6	2	0	0	6	3	6	9
Germany	21	17	8	3	1	1	8	2	0	0	8	5	10	15
Greece	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	2	1	0	0	0	0	0	0	0	0	0	0	1	1
Ireland	1	1	0	0	0	0	0	0	0	0	0	0	0	1
Italy	13	10	5	1	0	0	5	1	0	0	5	3	6	9
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	3	3	1	0	0	0	1	0	0	0	1	1	1	2
Poland	6	4	2	1	0	0	2	0	0	0	2	1	2	4

Scenario / Country	All Scenarios		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Years of Life Lived with Disability (DALYs)														
Portugal	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Romania	2	1	1	0	0	0	1	0	0	0	1	0	1	1
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Spain	5	4	2	1	0	0	2	1	0	0	2	2	5	8
Sweden	2	1	1	0	0	0	1	0	0	0	1	0	1	1
United Kingdom	17	11	4	1	0	0	4	1	0	0	4	2	3	5
TOTAL	106	79	34	9	3	3	34	9	1	1	35	21	40	63

Table 8.4.4 Numbers and proportions of the EU population ever exposed, by industry, men plus women

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Number ever exposed in the REP														
Manufacture of chemicals, chemical products and man-made fibres	11,942	12,020	12,130	12,047	11,977	11,977	12,130	12,047	11,977	11,977	13,965	15,689	17,354	19,410
Manufacture of Rubber Products	1,037	1,048	1,061	1,057	1,052	1,052	1,061	1,057	1,052	1,052	1,223	1,380	1,528	1,711
Research and development	398	479	561	628	664	664	561	628	664	664	432	373	288	147
Public administration and defence	1,421	1,711	2,003	2,244	2,373	2,373	2,003	2,244	2,373	2,373	1,520	1,285	955	426
Education	4,342	5,225	6,120	6,861	7,258	7,258	6,120	6,861	7,258	7,258	4,742	4,120	3,195	1,664
Health and Social Work	1,917	2,307	2,703	3,030	3,206	3,206	2,703	3,030	3,206	3,206	2,076	1,784	1,357	659

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Proportion of the population exposed (%)														
Manufacture of chemicals, chemical products and man-made fibres	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.005
Manufacture of Rubber Products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Research and development	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public administration and defence	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
Education	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.000
Health and Social Work	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000

Table 8.4.5 Occupational attributable fractions, deaths, registrations, YLLs and DALYs for lung cancer by industry, men plus women

Scenario	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
Industry sector	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Fraction (%)														
Manufacture of chemicals, chemical products and man-made fibres	0.016	0.010	0.004	0.001	0.000	0.000	0.004	0.001	0.000	0.000	0.004	0.002	0.004	0.006
Manufacture of Rubber Products	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Research and development	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Public administration and defence	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Health and Social Work	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Deaths														
Manufacture of chemicals, chemical products and man-made fibres	6	5	2	1	0	0	2	1	0	0	2	1	3	5
Manufacture of Rubber Products	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Research and development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public administration and defence	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and Social Work	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Registrations														
Manufacture of chemicals, chemical products and man-made fibres	20	15	6	2	1	1	6	2	0	0	7	4	7	11
Manufacture of Rubber Products	2	1	1	0	0	0	1	0	0	0	1	0	1	1
Research and development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public administration and defence	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and Social Work	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Years of Life Lost (YLLs)														
Manufacture of chemicals, chemical products and man-made fibres	74	55	24	7	2	2	24	6	1	0	24	15	29	45
Manufacture of Rubber Products	6	5	2	1	0	0	2	1	0	0	2	1	3	4
Research and development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public administration and defence	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and Social Work	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Scenario / Industry sector	All Scenario		Baseline scenario (1) - Current (2005) employment and exposure levels are maintained				Intervention scenario (2) - Assume 99% compliance for OEL = 0.1 ppm				Intervention scenario (3) - Assume 99% compliance for OEL = 1 ppm			
	2010	2020	2030	2040	2050	2060	2030	2040	2050	2060	2030	2040	2050	2060
Attributable Years of Life Lived with Disability (DALYs)														
Manufacture of chemicals, chemical products and man-made fibres	98	72	31	9	3	3	31	8	1	0	32	19	37	58
Manufacture of Rubber Products	8	6	3	1	0	0	3	1	0	0	3	2	3	5
Research and development	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public administration and defence	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Health and Social Work	0	0	0	0	0	0	0	0	0	0	0	0	0	0

8.5 VALUING HEALTH BENEFITS – INTERVENTION SCENARIOS

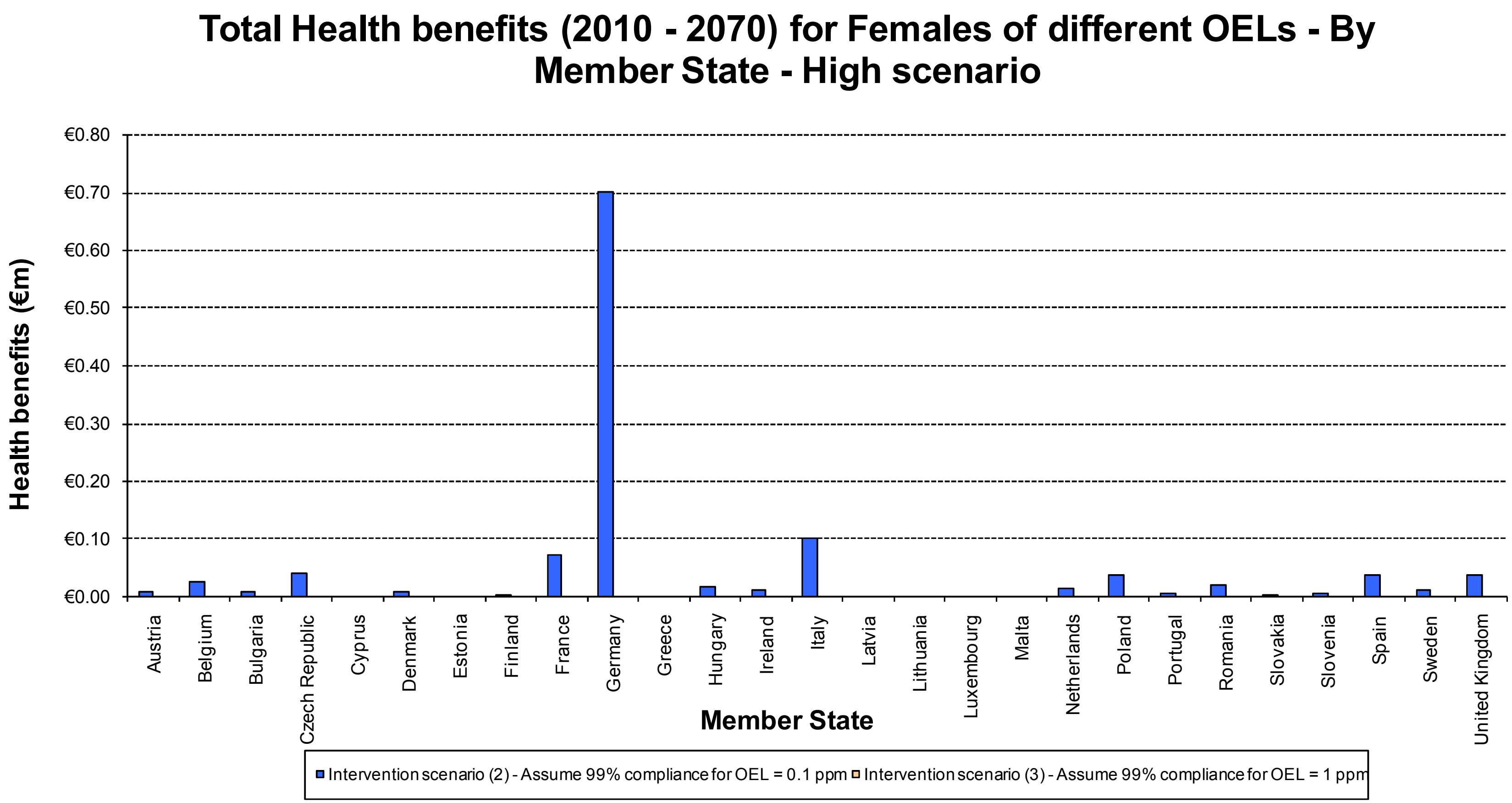

Figure 8.5.1 Total health benefits for females of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

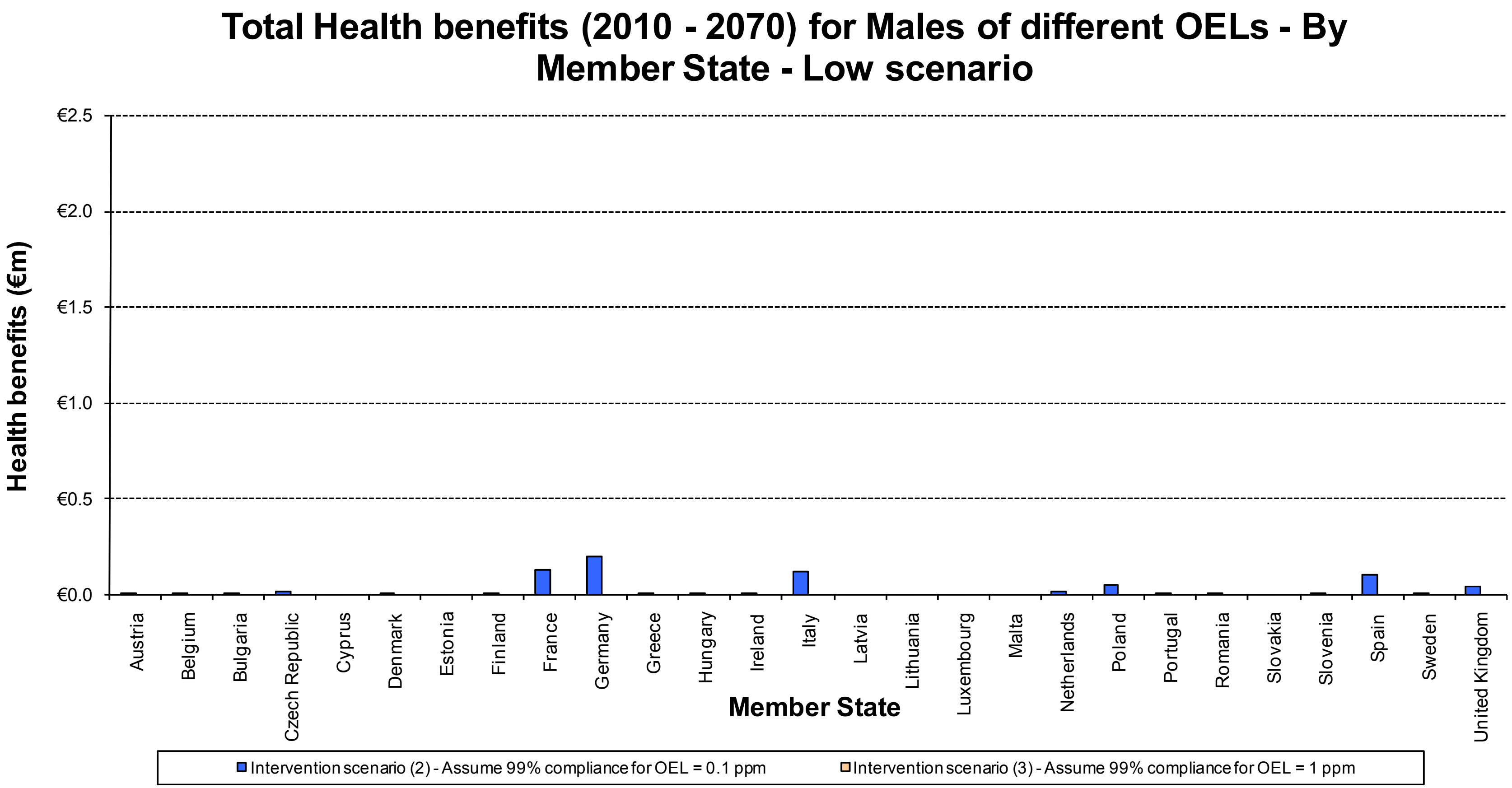

Figure 8.5.2 Total health benefits to males of introducing an EU wide OEL – By Member State – Low Scenario (Present Value – 2010 €m prices)

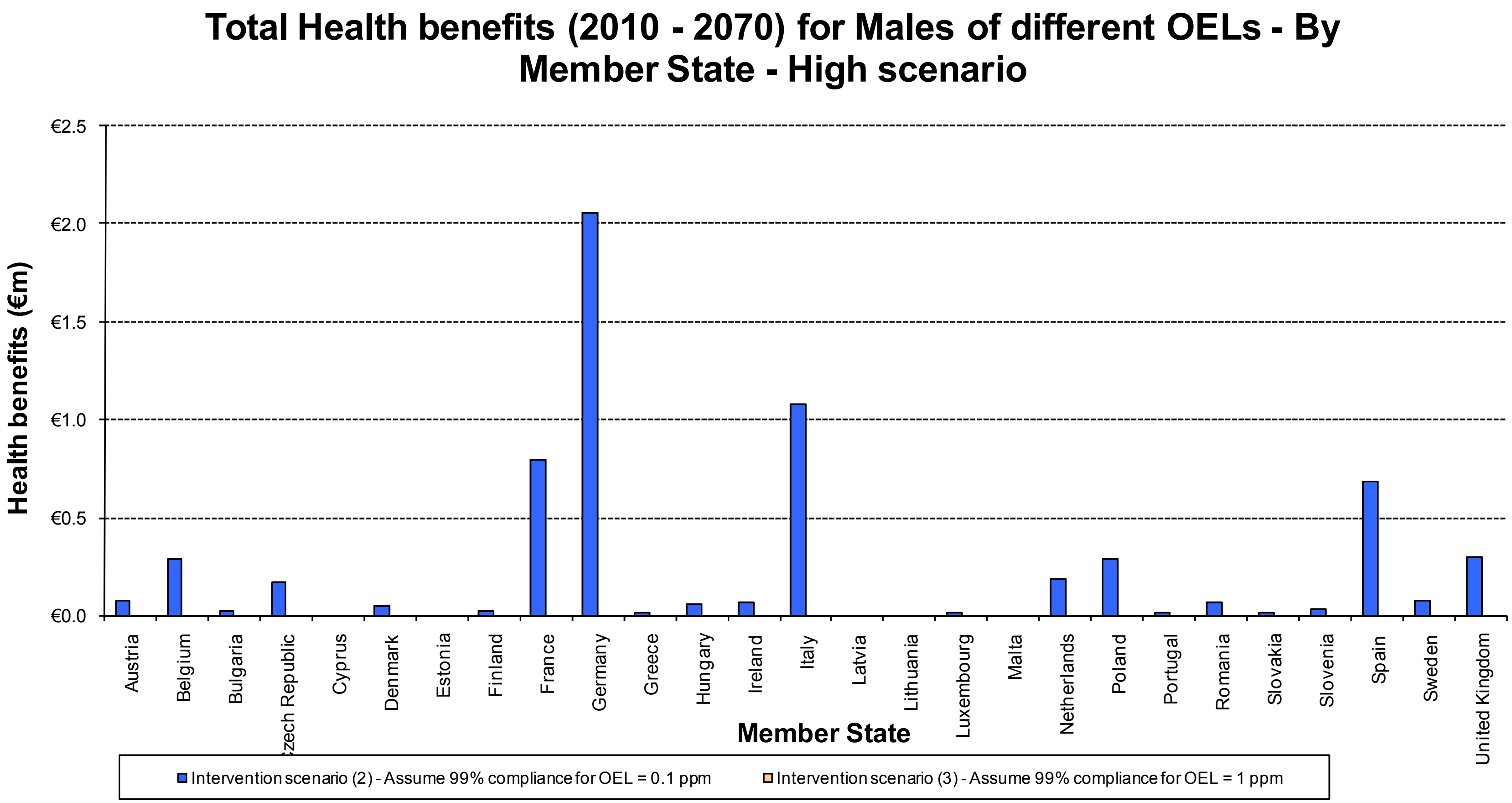

Figure 8.5.3 Total health benefits for males of introducing an EU wide OEL – By Member State – High Scenario (Present Value – 2010 €m prices)

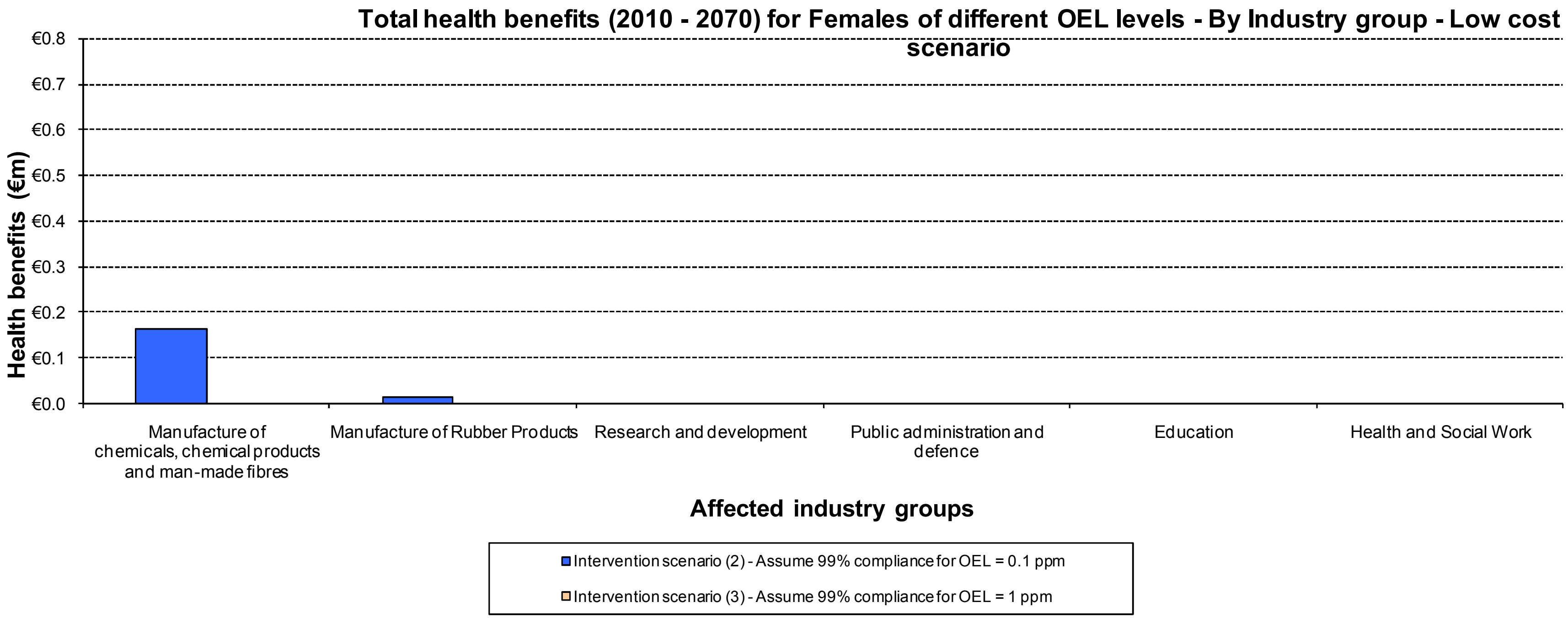

Figure 8.5.4 Total health benefits to females of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

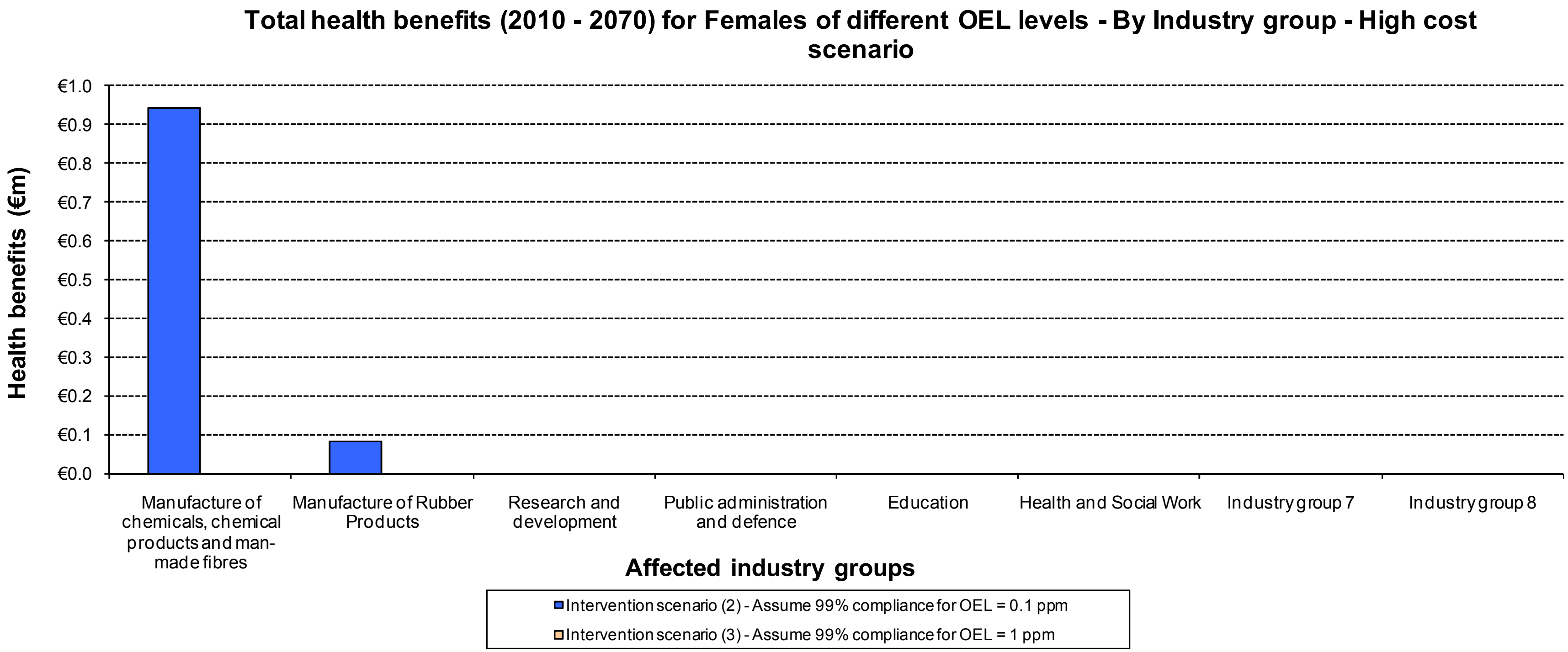

Figure 8.5.5 Total health benefits to females of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

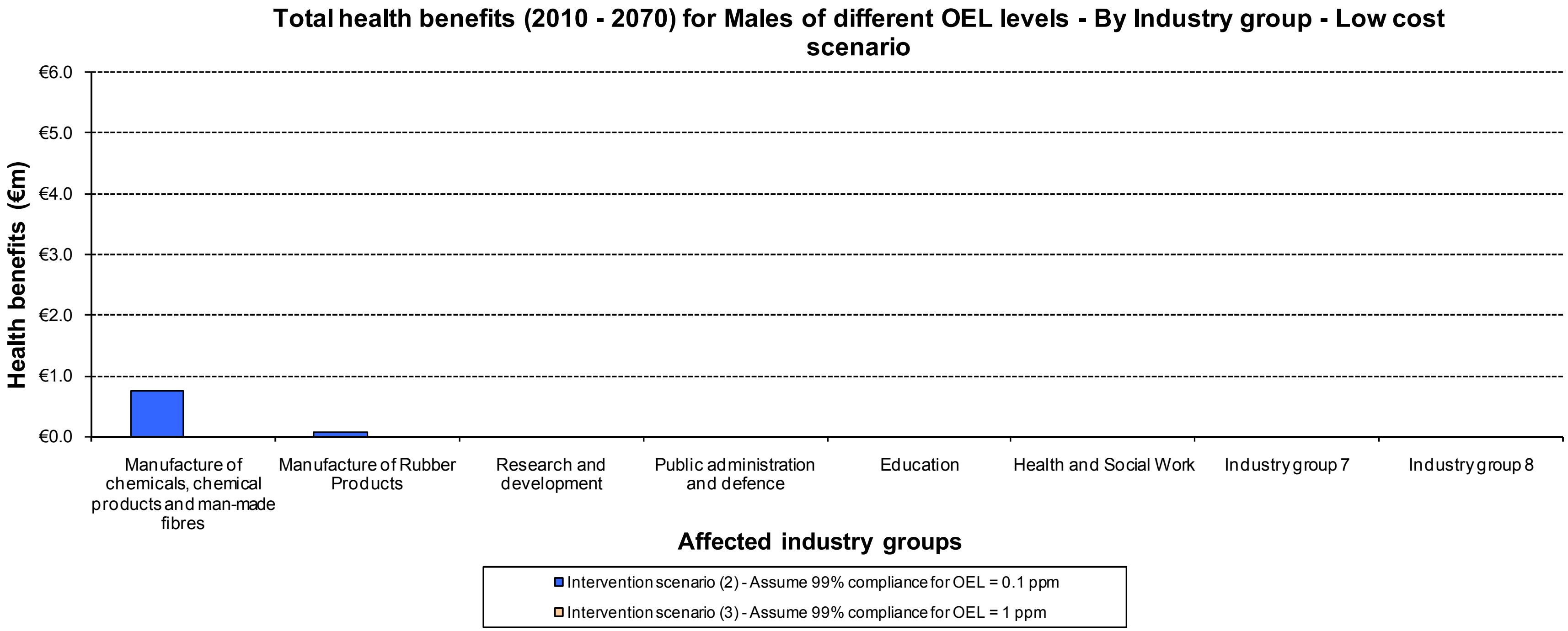

Figure 8.5.6 Total health benefits to males of introducing an EU wide OEL – By Industry Group – Low Scenario (Present Value – 2010 €m prices)

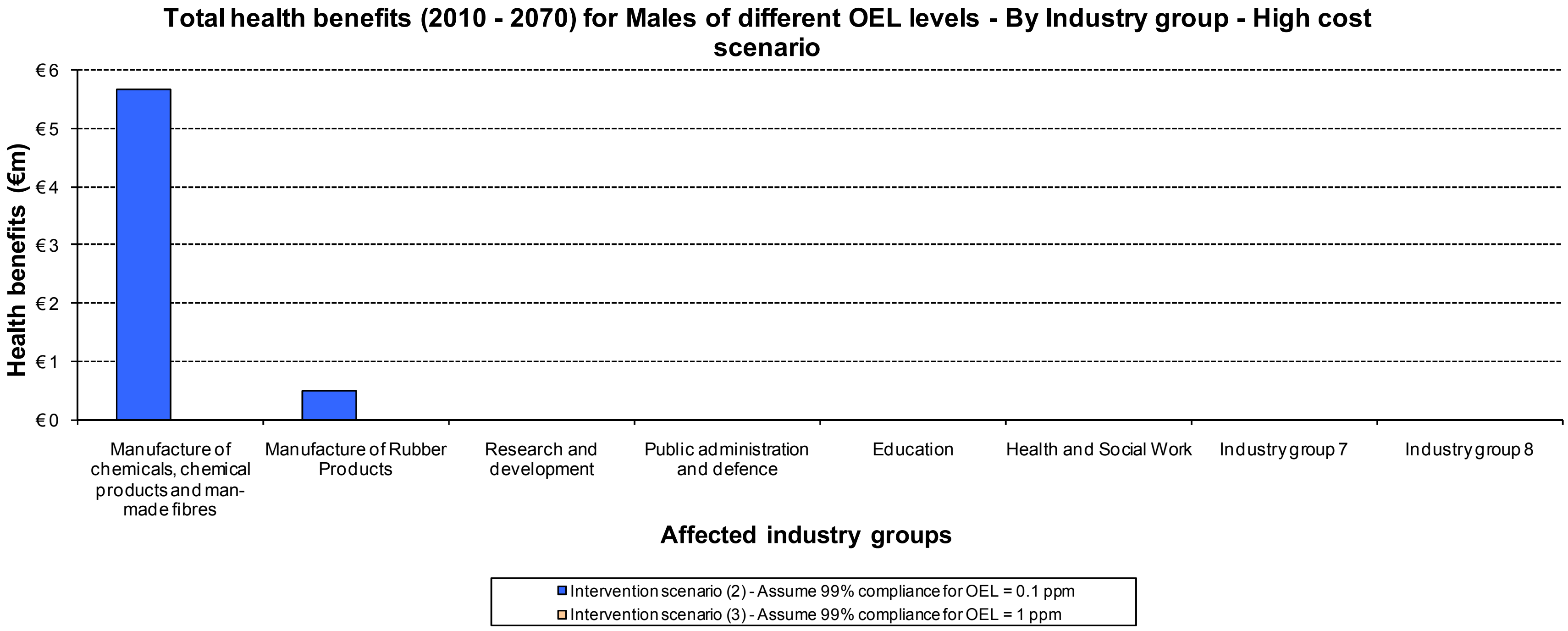

Figure 8.5.7 Total health benefits to males of introducing an EU wide OEL – By Industry Group – High Scenario (Present Value – 2010 €m prices)

8.6 HEALTH BENEFITS USING DIFFERENT DISCOUNT RATES

COLOUR KEY
No discount
Using the EU IA guidance - 4%
Using a declining discount rate (4% going to 3%)

Table 8.6.1 Introducing an OEL of 0.1ppm

1,3-butadiene	Option 3 - Assume full compliance for OEL = 0.1ppm						
Range of costs (€m)	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0.1 to 0.7	0.4 to 2.6	0.8 to 5
	Males	0 to 0	0 to 0	0 to 0.1	0.4 to 3.6	1.7 to 13.9	3.3 to 27
	Totals	0 to 0	0 to 0	0 to 0.1	0.5 to 4.3	2.1 to 16.4	4.1 to 31.9
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0.2	0.1 to 0.4	0.1 to 0.6
	Males	0 to 0	0 to 0	0 to 0	0.1 to 0.9	0.3 to 2.4	0.4 to 3.1
	Totals	0 to 0	0 to 0	0 to 0	0.1 to 1.1	0.4 to 2.8	0.5 to 3.7
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0.2	0.1 to 0.7	0.1 to 1
	Males	0 to 0	0 to 0	0 to 0.1	0.2 to 1.3	0.4 to 3.7	0.6 to 5.3
	Totals	0 to 0	0 to 0	0 to 0.1	0.2 to 1.5	0.5 to 4.3	0.8 to 6.3

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 0.1	€ 0.6	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Belgium	€ 0.1	€ 0.0	€ 0.0	€ 0.3	€ 0.0	€ 0.5
Bulgaria	€ 0.1	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.1
Czech Republic	€ 0.2	€ 0.1	€ 0.0	€ 0.2	€ 0.0	€ 0.3
Cyprus	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Denmark	€ 0.1	€ 0.1	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Estonia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Finland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
France	€ 1.0	€ 0.6	€ 0.2	€ 0.9	€ 0.2	€ 1.4
Germany	€ 2.0	€ 1.2	€ 0.3	€ 2.8	€ 0.5	€ 4.4
Greece	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Hungary	€ 0.1	€ 0.1	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Ireland	€ 0.1	€ 0.0	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Italy	€ 1.0	€ 0.6	€ 0.1	€ 1.2	€ 0.2	€ 1.9
Latvia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Lithuania	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Luxembourg	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Malta	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Netherlands	€ 0.1	€ 0.1	€ 0.0	€ 0.2	€ 0.0	€ 0.3
Poland	€ 0.4	€ 0.3	€ 0.1	€ 0.3	€ 0.1	€ 0.5
Portugal	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Romania	€ 0.1	€ 0.1	€ 0.0	€ 0.1	€ 0.0	€ 0.1
Slovakia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Slovenia	€ 0.1	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.1
Spain	€ 0.8	€ 0.5	€ 0.1	€ 0.7	€ 0.2	€ 1.2
Sweden	€ 0.1	€ 0.0	€ 0.0	€ 0.1	€ 0.0	€ 0.1
United Kingdom	€ 0.4	€ 0.2	€ 0.1	€ 0.3	€ 0.1	€ 0.5

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of chemicals, chemical products and man-made fibres	€ 6.3	€ 45.7	€ 0.9	€ 6.6	€ 1.5	€ 10.6
Manufacture of Rubber Products	€ 0.6	€ 4.1	€ 0.1	€ 0.6	€ 0.1	€ 0.9
Research and development	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Public administration and defence	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0.0
Education	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Health and Social Work	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0

Table 8.6.2 Introducing an OEL of 1ppm

1,3-butadiene	**Option 4 - Assume full compliance for OEL = 1ppm**						
Range of costs (€m)	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Gender	2010-2019	2020-2029	2030-2039	2040-2049	2050-2059	2060-2069
	Females	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Males	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0
	Totals	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0	0 to 0

Member State	Low cost	High cost	Low cost	High cost	Low cost	High cost
Austria	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Belgium	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Bulgaria	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Czech Republic	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Cyprus	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Denmark	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Estonia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Finland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
France	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Germany	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Greece	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Hungary	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Ireland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Italy	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Latvia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Lithuania	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Luxembourg	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Malta	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Netherlands	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Poland	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Portugal	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Romania	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Slovakia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Slovenia	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Spain	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
Sweden	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0
United Kingdom	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0	€ 0.0

Industry Group	Low cost	High cost	Low cost	High cost	Low cost	High cost
Manufacture of chemicals, chemical products and man-made fibres	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Manufacture of Rubber Products	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Research and development	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Public administration and defence	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Education	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Health and Social Work	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0

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