Executive Summary

In preparation for the Transport Environment and Health Session of the WHO Ministerial Conference on Environment and Health, to be held in London in June 1999, a tri-lateral project was carried out by Austria, France and Switzerland. This project assessed the health costs of road traffic-related air pollution in the three countries using a common methodological framework.

From the French side, this tri-lateral research has been selected as part of the French co-ordinated research program on transport (PREDIT)[1] by both steering groups of PREDIT in charge of research co-ordination in the field of health effects of transport related pollution and externalities' monetarisation. This underlines the commitment of the PREDIT towards international co-operation.

In addition to its positive impact on the growth and prosperity of the national economy and its importance for satisfying our individual needs for mobility, road transport also has adverse effects: accidents, noise, air pollution, harm to health, crop damage, traffic jams, etc. These costs are mainly external costs which means that they are not covered by the polluters (the motorists) but that they are imposed on everybody.

In the present tri-lateral project, information about air pollution related effects on human health and the share of traffic-related air pollution was assessed by integrating data on air pollution, epidemiology and economy. The tasks of the three domains may be summarised as follows:

1. **Air pollution: Evaluation of the (road traffic-related) exposure**
   For the three countries Austria, France and Switzerland, the exposure of the residential population to PM10 had to be assessed and the results presented in a fine register defining the population's exposure by concentration classes.

2. **Epidemiology: Evaluation of the exposure-response relationship between air pollution and health impacts**
   The relationship between air pollution and health had to establish to what extent different levels of air pollution affect a population's morbidity and mortality.

3. **Economy: Evaluation of the road traffic-related health impacts and their monetarisation**
   By combining the exposure-response relationship with the exposure to PM10 in each country, the impacts of traffic related air pollution on human health had to be quantified (additional cases of premature death and number and type of additional cases of morbidity) and valued in monetary terms.

[1] The PREDIT is a joint research program developed and supported by following institutions: Ministry of Transport, Ministry of Research, Ministry of Industry, Ministry of Environment, ADEME French Agency for Environment and Energy Management, ANVAR French Agency for Research Valorisation.

Based on the average yearly population exposure to particulate matter with an aerodynamic diameter of less than 10 μm (PM10) and the exposure-response function for a number of different health outcomes, the following number of cases attributable to (road traffic-related) air pollution was estimated:

Table E-1: Air pollution attributable health outcomes in Austria, France and Switzerland (1996)

Health outcome	Additional cases or days due to air pollution					
	Cases or days attributable to total air pollution			Cases or days attributable to road traffic		
	Austria	France	Switzerland	Austria	France	Switzerland
Long-term mortality (adults≥30 years)	5‘576 3‘370-7‘813	31‘692 19‘202-44‘369	3’314 1‘986-4‘651	2‘411 1‘457-3‘378	17’629 10‘681-24‘680	1’762 1‘056-2‘472
Respiratory hospital admissions (all ages)	3’399 358-6456	13’796 1‘491-26‘286	1‘308 138-2‘488	1‘470 155-2‘792	7’674 829-14‘622	694 73-1‘320
Cardiovascular hospital admissions (all ages)	6‘695 3‘489-9‘960	19‘761 10‘440-29‘362	2‘979 1‘544-4‘425	2‘895 1‘509-4‘307	10’992 5‘807-16‘333	1‘580 819-2‘348
Chronic bronchitis incidence (adults ≥25 years)	6‘158 552-12‘241	36’726 3‘262-73‘079	4‘238 374-8‘436	2‘663 239-5‘293	20’429 1‘814-40‘650	2‘248 199-4‘475
Bronchitis (children < 15 years)	47‘652 21‘008-86‘090	450’218 198‘450-813‘562	45‘446 20‘029-82‘121	20‘606 9‘085-37‘228	250’434 110‘388-452‘544	24‘109 10‘626-43‘565
Restricted activity days (adults ≥20 years)	3'106‘544 2'615‘175-3'604‘519	24'579‘872 20'692‘055-28'519‘982	2‘762‘682 2‘325‘699-3'205‘536	1‘343‘371 1'130‘886-1'558‘711	13'672‘554 11'509‘956-15'864‘240	1'465‘600 1'233‘782-1'700‘534
Asthmatics: asthma attacks (children < 15 years)	34’665 21‘321-48‘174	242‘633 149‘141-337‘151	23’637 14‘532-32‘850	14‘990 9‘220-20‘832	134’965 82‘960-187‘540	12’539 7‘709-17‘427
Asthmatics: Asthma attacks (adults ≥ 15 years, person days)	93’619 45‘594-142‘598	577’174 281‘130-879‘091	62‘593 30‘490-95‘345	40‘484 19‘716-61‘664	321‘053 156‘378-488‘994	33‘205 16‘175-50‘580

All air pollution-related health effects are only considered for the age groups assessed by epidemiological surveys and above the lowest assessed exposure level of 7.5 μg/m^3 PM10. Due to the larger population size, the number of health outcomes in France are much larger compared to Austria and Switzerland.

Using the willingness-to-pay as a common methodological framework for the monetary valuation, material costs such as medical costs and loss of production or consumption as well as the intangible costs for pain, suffering, grief and loss in life quality were considered. The monetary valuation provided the following results:

Table E-2: Air pollution related health costs in Austria, France and Switzerland in 1996 based on the willingness-to-pay approach*

	Austria		France		Switzerland	
	Costs attributable to total air pollution	Costs attributable to road traffic	Costs attributable to total air pollution	Costs attributable to road traffic	Costs attributable to total air pollution	Costs attributable to road traffic
Costs of mortality (Mio. EUR)	**5 019** 3'033-7'031	**2 170** 1'311–3'041	**28 523** 17'282-39'932	**15 866** 9'613 – 22'212	**2 983** 1'787–4'186	**1 586** 950 – 2'225
Costs of morbidity (Mio. EUR)	**1 669** 396-3 044	**722** 171–1 316	**10 335** 2 760–18537	**5 749** 1 535–10311	**1 188** 314– 2 134	**630** 167–1132
Total costs (Mio. EUR)	**6 687** 3 429-10 075	**2 892** 1 483-4 357	**38 858** 20 042-58 469	**21 615** 11 148-32 523	**4 170** 2 101-6 319	**2 216** 1 117-3 357

*willingness-to-pay for a prevented fatality = 0.9 million EUR

All three countries together bear some **49 700 million EUR** of air pollution related health costs, of which some **26 700 million EUR** are road-traffic related. Due to the similar size of their population, in Austria and Switzerland the air pollution related health costs reach similar levels.
In each country, the **mortality costs are predominant**, amounting to **more than 70 %** . Since the same methodology was used in all three countries and the environmental, medical and socio-economic context is quite similar for the three neighbouring countries, the similarity of the results is not astonishing. Within the costs of morbidity, in all three countries together the highest value arises from **chronic bronchitis (74%)** followed by the costs for **restricted activity days (22%)**. For chronic bronchitis, the willingness-to-pay for avoiding this health outcome is considerable (209'000 EUR per case), as this disease signifies a low health status with major constraints to the wellbeing of a victim. For the restricted activity days, although a relatively low willingness-to-pay value of 94 EUR per day is recorded, it is the high number of such days - 30'450'000 days for all three countries together – that inflates the total amount of costs.

Comparing the national per capita costs of air pollution related health effects shows a similar range of values for all three countries for the total air pollution related per capita health costs of **425-1 250 EUR for Austria**, **344-1 004 EUR for France** and **297-892 EUR** for Switzerland. Considering the per capita health costs due to road traffic-related air pollution, the differences between the countries are even lower with a range from **184-541 EUR for Austria (central value 359 EUR)**, **191-588 EUR for France (central value 371 EUR)** and **158-474 EUR for Switzerland (central value 313 EUR)**.

The results of the present study underline the need for action: A periodic observation of the air pollution related health costs based on standardised European methodology has to provide necessary information for a health impact assessment on which effective policy measures of internalisation may be based.

Summary

In preparation for the Transport Environment and Health Session of the WHO Ministerial Conference on Environment and Health, to be held in London in June 1999, a tri-lateral project was carried out by Austria, France and Switzerland. This project assessed the health costs of road traffic-related air pollution in the three countries using a common methodological framework.

From the French side, this tri-lateral research has been selected as part of the French co-ordinated research program on transport (PREDIT)[2] by both steering groups of PREDIT in charge of research co-ordination in the field of health effects of transport related pollution and externalities' monetarisation. This underlines the commitment of the PREDIT towards international co-operation.

Introduction

Context

In addition to its positive impact on the growth and prosperity of the national economy and its importance for satisfying our individual needs for mobility, road transport also has adverse effects: accidents, noise, air pollution, harm to health, crop damage, traffic jams, etc.

In the last 10 to 20 years an increasing awareness may be observed for these negative effects of transport. Congestion, air pollution and noise affect more and more people. Their impact on health and welfare, the damage to buildings and the natural environment are considerable, just like the material and intangible costs caused by them.

These costs are mainly external costs which means that they are not covered by the polluters (the motorists) but that they are imposed on everybody. External costs cause a problem to the economy, as they are not included in the market price which leads to wrong decisions and to a wasting of scarce and vital resources (clean air, silence, clean water, etc.). Motorists behave as if those costs do not exist, since they have not to pay for them. By including the external costs, some trips may have produced higher total costs than the total benefit. As a consequence, these trips would have been avoided if all the external costs had to be considered by the driver.

In order to stop the wasting of scarce resources, the government has to take action and put a price on clean air and other environmental "products". As a result, negative impacts of road transport have to be paid for by the polluter. The usual terminology for this process is "internalisation of externalities".

A condition for such an environmental and transport policy is a knowledge about the negative impacts of road traffic and their monetary quantification.

[2] The PREDIT is a joint research program developed and supported by following institutions: Ministry of Transport, Ministry of Research, Ministry of Industry, Ministry of Environment, ADEME French Agency for Environment and Energy Management, ANVAR French Agency for Research Valorisation.

With the present project, an important part of the external traffic-related costs, namely the **negative impacts of road traffic-related air pollution on human health**, is evaluated and quantified in monetary terms.

Objective

In order to **quantify the road traffic related health costs due to air pollution**, Austria, France and Switzerland have co-operated in a tri-lateral research project.

One objective is the choice of a common methodological framework and the evaluation of results that are comparable for the three countries. Of course, within the common methodological framework, some specific features of each country (data availability, health system, etc.) must be considered.
The results of this co-operation provide an input for the WHO Ministerial Conference in June 1999[3].

The research project is based on an interdisciplinary co-operation in the fields of air pollution, epidemiology and economy. The tasks of the three domains may be summarised as follows:

1. **Air pollution: Evaluation of the (road traffic-related) exposure**
   For the three countries Austria, France and Switzerland, the exposure of the residential population to PM10 had to be assessed. The result had to be presented as a fine register that describes the population's exposure by concentration classes. It had to be considered that the emissions' source is not only transport but other sources as well, such as industry and households.

2. **Epidemiology: Evaluation of the exposure-response relationship between air pollution and health impacts**
   The relationship between air pollution and health had to be assessed. This step provides for each level of exposure the number of air pollution attributable cases of morbidity and mortality. This evaluation had to be based on the current epidemiologic evidence.

3. **Economy: Evaluation of the road traffic-related health impacts and their monetarisation**
   By combining the exposure-response relationship with the exposure to PM10 in each country, the impacts of traffic related air pollution on human health had to be quantified (number and type of additional cases of morbidity, number of additional cases of premature death) and valued in monetary terms.

The common methodological framework of each of the above mentioned scientific domains and the corresponding results of PM10 population exposure, of air pollution attributable health effects and of the monetary valuation of the air pollution related health effects are presented in detail in three separate technical reports.

[3] Third WHO Ministerial Conference on Environment & Health, London, 16-18 June 1999.

Findings

As one single indicator for urban air pollution, the assessment was limited to particulate matter of less than 10 µm aerodynamic diameter (PM10). For Austria, France and Switzerland the population exposure with PM10 shows relatively similar results, especially concerning the PM10 concentration caused by road traffic (Table S-1).

Table S-1: Population weighted annual average PM10 exposure for Austria, France and Switzerland

PM10 concentration in µg/m^3 (annual mean)	**Austria**	**France**	**Switzerland**
Total PM10	26.0	23.5	21.4
Road-traffic related PM10	8.0	8.9	7.4

Effect estimates from epidemiologic studies are a key component for the assessment of air pollution impacts on health. If available, short- and long-term effects were considered for the assessment. However, overlapping health measures had to be excluded in order to prevent double counting of the impact, especially when monetarizing the effects.

In the present study, the following health outcomes were selected: total mortality based on cohort studies, respiratory hospital admissions, cardiovascular hospital admissions, chronic bronchitis in adults, acute bronchitis in children, restricted activity days in adults, asthma attacks in children and asthma attacks in adults.

For each health endpoint, epidemiologic exposure-response curves were derived from the available literature, using a meta-analytic approach to calculate the variance weighted mean relative risks and applied to the national epidemiologic baseline data for each health outcome (incidence, prevalence). For the three countries, the following number of cases attributable to total air pollution and to road traffic-related air pollution was assessed for 1996 (Table S-2):

Table S-2: Air pollution attributable health outcomes in Austria, France and Switzerland (1996)

Health outcome	Additional cases or days due to air pollution					
	Cases or days attributable to total air pollution			Cases or days attributable to road traffic		
	Austria	France	Switzerland	Austria	France	Switzerland
Long-term mortality (adults≥30 years)	5‘576 3‘370-7‘813	31‘692 19‘202-44‘369	3’314 1‘986-4‘651	2‘411 1‘457-3‘378	17’629 10‘681-24‘680	1’762 1‘056-2‘472
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All air pollution-related health effects are only considered for the age groups assessed by epidemiological surveys and above the lowest assessed exposure level of 7.5 µg/m^3 PM10.

In 1996, air pollution caused some 5 600 cases of **premature death** in Austria, some 31 700 cases in France and some 3 300 cases in Switzerland. In Austria 2 400, in France 17 600 and in Switzerland 1 800 cases are attributable to road traffic-related air pollution. According to the epidemiological surveys, the increase in premature mortality is only considered for adults ≥30 years of age.

Within the **additional morbidity cases** attributable to road traffic, the highest incidence in all three countries is registered for **acute bronchitis in children** younger than 15 years. Some 21 000 cases in Austria, some 250 000 cases in France and some 24 000 cases in Switzerland were attributable to road traffic-related air pollution in 1996.

The second highest frequency is obtained for the incidence of **chronic bronchitis in adults.** In 1996, the number attributable to road traffic-related air pollution amounts to ca 2‘700 cases in Austria, 20'400 cases in France and 2 200 cases in Switzerland.

Concerning the **additional days** of air pollution related morbidity, a very large number of **restricted activity days** for adults (≥ 20 years) was registered in all three countries. In 1996, in Austria 1.3 million days, in France 13.7 million days and in Switzerland 1.5 million days with restricted activity were attributed to road-traffic-related air pollution.

As may be seen later from the monetary valuation, the premature mortality, the incidence in chronic bronchitis and the very high number of restricted activity days will be of particular relevance for the overall result.

For the monetary valuation of the air pollution related health outcomes, the willingness-to-pay approach was chosen as a common methodological framework. This approach is based on a theoretical foundation of welfare economics in considering the individual utility improvement for a reduction in health related risk. It includes the material costs for ambulant or stationary medical treatment, the loss of capacity leading to production and consumption losses as well as intangible costs of pain, fear, suffering and loss in life quality due to air pollution related health effects. The cost factors applied in the present study are chosen from the most recent economic literature. For the premature mortality the most recent empirical values for the willingness-to-pay of a risk reduction of fatal road accidents of 1.4 million EUR per prevented fatality were applied and corrected downwards to **0.9 million EUR** (Table S-3). This correction considers the lower willingness-to-pay of the higher average age class of air pollution related victims.

Table S-3: Air pollution related health costs in Austria, France and Switzerland in 1996 based on the willingness-to-pay approach (VPF 0.9 Mio. EUR)

	Austria		**France**		**Switzerland**	
	Costs attributable to total air pollution	Costs attributable to road traffic	Costs attributable to total air pollution	Costs attributable to road traffic	Costs attributable to total air pollution	Costs attributable to road traffic
Costs of mortality (Mio. EUR)	**5 019** 3'033-7'031	**2 170** 1'311–3'041	**28 523** 17'282-39'932	**15 866** 9'613 – 22'212	**2 983** 1'787–4'186	**1 586** 950 – 2'225
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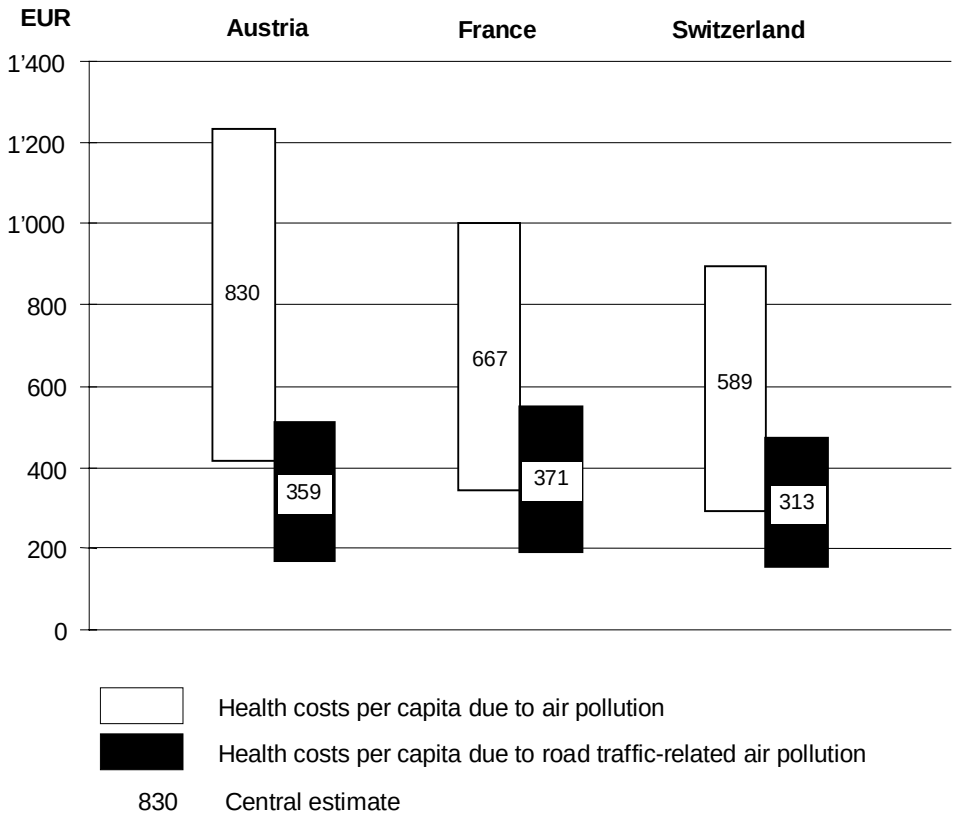
All three countries together bear some 49 700 million EUR of air pollution related health costs, of which some 26 700 million EUR are road-traffic related. Due to the similar size of their population, in Austria and Switzerland the air pollution related health costs reach similar level.
In each country, the **mortality costs are predominant**, amounting to **more than 70 %** . Since the same methodology was used in all three countries and the environmental, medical and socio-economic context is quite similar for the three neighbouring countries, the similarity of the results is not astonishing. Within the costs of morbidity, in all three countries together the highest value arises from **chronic bronchitis (74%)** followed by the costs for **restricted activity days (22%)**. For chronic bronchitis, the willingness-to-pay for avoiding this health outcome is considerable (209'000 EUR per case), as this disease signifies a low health status with major constraints to the wellbeing of a victim. For the restricted activity days, although a relatively low willingness-to-pay value of 94 EUR per day is recorded, it is the high number of such days - 30'450'000 days for all three countries together – that inflates the total amount of costs.

Comparing the national per capita costs of air pollution related health effects (Figure S-4) shows a similar range of values for all three countries for the total air pollution related per capita health costs of **425-1 250 EUR for Austria**, **344-1 004 EUR for France** and **297-892 EUR** for Switzerland. Considering the per capita health costs due to road traffic-related air pollution, the differences between the countries are even lower with a range from **184-541 EUR for Austria (central value 359 EUR)**, **191-588 EUR for France (central value 371 EUR)** and **158-474 EUR for Switzerland (central value 313 EUR)**.

Figure S-4 Air pollution related health costs per capita (1996)



The sensitivity of the above presented results is influenced by all three scientific domains, the assessment of PM10 exposure, the air pollution attributable health outcomes and the monetary valuation of the health effects. In general, for each sensitive assumption an ”at least” approach was adopted. The health costs assessed according to the common methodological framework may be considered to be a conservative estimation of the real costs, since

- different PM10 related health effects (e.g. lung cancer, infant mortality) were not considered in absence of available data,
- the additional effects of other pollutants (e.g. ozone) were not considered,
- for the monetary valuation generally prudent cost factors were chosen.

The Charter on Transport, Environment and Health on behalf of the WHO Ministerial Conference on Environment and Health in London 1999, states as a primary goal the achievement of a transport system, sustainable with regards to health and environment. The results of the present case study draw attention to the high impact of (road traffic-related) air pollution on human health, thus underlying the necessity for a re-orientation of both research policy and implementation policy.

First of all, a standardised methodology and technique for a periodic assessment of the populations exposure, and the health and environmental status of that population has to be established in order to provide a comparable monitoring system throughout the European countries. Second, the periodic results from the air pollution related health assessment need to be integrated into the health and environmental impact assessment tools in general, into national accounting systems (e.g. traffic account) and into cost-benefit analysis for specific projects. Finally, an improvement of the different information tools is needed to strengthen the basis for a policy design which aims at the implementation of the polluter-pays principle (e.g. by re-orienting the tax system), which should induce a reduction in air pollution as well as savings in the health system costs in the long run.