anses
French agency for food, environmental and occupational health & safety

The Director General

Maisons-Alfort, 9 April 2014

Note and recommendations

of the French Agency for Food, Environmental and Occupational Health & Safety

on the "Study of the socio-economic cost of indoor air pollutants" research and development agreement

---

1. Background

The *exploratory study of the socio-economic cost of indoor air pollutants* is the result of a research and development agreement (CRD) contracted between the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), Pierre Kopp, professor of economics at the Pantheon-Sorbonne University, and the French Indoor Air Quality Observatory (OQAI). This work was presented and discussed at the meetings of 4 February, 17 April and 27 September 2013 of ANSES's "Human, social and economic sciences" expert group, at the meetings of 14 May and 5 September 2013 of ANSES's Expert Committee on "Assessment of the risks related to air environments" and at the meetings of 23 January and 27 September 2013 of the OQAI's Scientific Board.
Besides the health aspects, this study offers an economic perspective of a public health issue with the aim of providing additional information, mainly to policy makers, for identifying appropriate preventive measures.

2. Synthesis of the study

2.1. Introduction

The quality of air inside buildings is a public health concern in France and many other countries. In temperate climates, each individual spends nearly 90% of their time in indoor environments, mainly in the home. Indoor environments offer a wide variety of situations of exposure to many physical agents and chemical or microbiological contaminants. The health consequences of such exposure vary widely depending on the nature of the pollutants, and the intensity and duration of exposure. Their occurrence depends on other factors such as genetic determinants, socio-economic factors and other environmental parameters.
The public health consequences of these situations are today often difficult to quantify precisely, given the available data. In this context, the desire to further knowledge was set down in the first French National Environment and Health Action Plan (PNSE I, 2004-2008),

then confirmed as part of the *Grenelle* Environmental round table (2007) and in the PNSE II (2009-2013). This theme is one of the priorities for action of Planning Act No. 2009-967 of 3 August 2009 on the implementation of the *Grenelle* Environmental round table (see Articles 37 and 40) and of Act No. 2010-788 of 12 July 2010 on the national commitment to the environment (see Article 180).
Issues relating to indoor air are a major topic of investigation for ANSES. The work conducted at the Agency has led to the development of an exploratory method for quantifying the economic consequences of the impact of certain indoor air pollutants on the health of the population in France, for a given year, without distinguishing between the different types of indoor environments.
An indoor air pollutant is defined as any pollutant found in the air of enclosed environments regardless of its source, whether it is specific to this environment and its occupants (heating, cooking, furniture, cleaning products, etc.) or external to it, such as ambient air pollution for example.

2.2. MATERIALS AND METHODS

2.2.1. Health impact assessment

This first step aimed to test the method for assessing the health impact through a selection of six pollutants: benzene, radon, trichlorethylene, carbon monoxide, particulate matter and environmental tobacco smoke.
These pollutants were chosen based firstly on the availability of data on exposure of the general population in representative samples of French housing (OQAI data), and secondly on the existence of a dose-response relationship or published health data, related to expert appraisals on indoor air quality guideline values (IAQGs) carried out by ANSES. This choice limited the list of pollutants that could be considered; the method of calculating the health impact was adapted based on the available data meeting these criteria. Thus, several approaches were followed to estimate the impact of the selected indoor air pollutants.
In view of the availability of the data that enabled this study to proceed, the base year chosen was 2004.

Benzene, Trichlorethylene: Assessment of excess collective health risks (CER)

A calculation to assess collective risk was carried out for benzene and trichlorethylene based on the principles of quantitative health risk assessment.
The collective excess risk (CER) for benzene and trichlorethylene was calculated by multiplying:

- the excess unit risk of the substance based on the recent ANSES expert appraisal on the reference values;
- the median concentration of the substance measured during the 2003-2005 housing survey conducted by the OQAI. The value was extrapolated to all indoor environments in the absence of representative data for other types of living areas;
- time adjustment factors taking into account life expectancy and/or the average time spent by the population in indoor environments (90% for this exercise) and, for trichlorethylene, adjustment factors to calculate carcinogenic risks to children, called age-dependent adjustment factors (ADAFs).

Then an individual excess risk (IER) was calculated and multiplied by the number of individuals in France according to the INSEE[1] census for 2004, in order to estimate the number of deaths associated with acute leukaemia for benzene and kidney cancer for trichlorethylene.

[1] National Institute of Statistics and Economic Studies

Particulate matter ($PM_{2.5}$ fraction): Health impact assessment

A calculation of the health impact was carried out for particulate matter ($PM_{2.5}$ fraction) based on the relative risks (RRs) from epidemiological studies on the risks associated with ambient air pollution. Other epidemiological studies have shown health effects for PM_{10} and $PM_{2.5}$. Regarding the impact calculations, only the effects associated with long-term exposure were considered when selecting $PM_{2.5}$; it should be noted that most total effects are attributable to long-term exposure. Regarding the concepts and methods relating to the health impact assessment, the follow-up to the exercise was explicitly based on the approach used in the Aphekom study (Declercq 2012).

Several assumptions were made for this exercise. Time-series studies explore the exposure-risk relationships established for ambient air, between particles defined as indicators of urban pollution, whose measurement corresponds to levels at urban-background stations, and health indicators (morbidity/mortality). Thus, it was clearly assumed that the effects associated with urban particulate matter were analogous to those of indoor air particles. Moreover, it was decided for this exploratory approach to equate all indoor environments (work, transport, etc.) to housing in terms of median levels of indoor $PM_{2.5}$ concentrations. Lastly, only non-smoking households were selected for defining concentration levels, as the presence of smokers increases particulate concentrations, especially related to environmental tobacco smoke. This has specific toxicity and the issue of environmental tobacco smoke is treated separately below. The impact was calculated considering the population aged 30 and over, using the same relative risk (RR) for all age groups.

The health impact assessment was based on the following data:

1 mean RRs (death from all causes, cardiovascular causes and lung cancer) for a 10 $\mu g.m^{-3}$ increase in the concentration of $PM_{2.5}$, from the study by Pope *et al.*, (2002) on the American Cancer Society (ACS) cohort;
2 the annual number of deaths, excluding violent deaths, observed in 2004, according to Inserm's CépiDc (Centre for epidemiology on the medical causes of death) census;
3 the difference in concentrations measured during the OQAI's 2003-2005 housing survey, between an indoor environment polluted by indoor and outdoor sources (median of the distribution for non-smoking households) and an indoor environment devoid of sources of pollution (5^{th} percentile of the distribution for non-smoking households);
4 a time adjustment factor taking into account the average time spent by the population in indoor environments without distinction (90% for this exercise).

Although the number of years of life lost due to mortality from all causes was estimated for the population aged 30 and over, only the values for loss of life expectancy by disease were used for the economic aspect.

A proportion of the deaths from "all causes" is unexplained. It seems reasonable to assume that it relates to respiratory diseases and the assumption was made that chronic obstructive pulmonary diseases (COPDs) are seen as representative of this group of diseases.

Thus, ultimately three diseases were associated with exposure to particulate matter and considered in the calculations: lung cancer, COPD and cardiovascular diseases.

Radon, environmental tobacco smoke, carbon monoxide: Assessing the health impact from the available incidence data

The incidence data available for the entire French population for radon, environmental tobacco smoke and carbon monoxide were identified in the literature and used directly for this exercise. A literature review was conducted to gather the most relevant data meeting the criteria on quality, time (closest to 2004) and space (for France). It was thus possible to analyse and use information on radon, carbon monoxide and environmental tobacco smoke.

The annual number of deaths from lung cancer that may be attributable to domestic radon exposure in France (Catelinois *et al.*, 2007) ranges from 1234 (90% uncertainty interval: 593-2156) to 2913 (90% uncertainty interval: 2763-3221) depending on the exposure-response relationships used. An arithmetic mean was calculated between these two values to obtain a single number of deaths.
Concerning carbon monoxide, the incidence and mortality data for 2000-2004 come from the monitoring system for CO poisoning recorded in different registers. They take into account death certificates processed by the CépiDC.
Concerning environmental tobacco smoke, a report published in 2006 under the aegis of the European Cancer Society, Cancer Research UK, the European Health Network and INCa, entitled *"Lifting the smokescreen: 10 reasons for a smoke free Europe"* provides estimates of the number of deaths associated with environmental tobacco smoke for 2002. These data were selected to estimate the impact of environmental tobacco smoke in France. The deaths considered are those in relation to lung cancer, cerebrovascular diseases (mainly stroke), ischemic heart disease (mainly myocardial infarction), and chronic lower respiratory tract diseases (mainly COPDs).

The calculations made and the data selected provided an estimate of the annual number of deaths in the general population for the year 2004. Morbidity related to exposure to these indoor air pollutants was also estimated. To calculate this, the relationship between the incidence of the disease (acute leukaemia, kidney cancer, lung cancer, COPD, cardiovascular diseases) and the annual number of deaths in the general population was determined and then multiplied by the number of deaths attributable to the disease associated with exposure to the indoor air pollutant.
INCa (2007) and WHO (2004) data provided information on survival time with the disease in question, the loss of quality of life and life-years lost.

The results are shown in Table 1

Table 1: Estimate of the health impact associated with exposure to each of the six indoor air pollutants studied

		Age at death	Survival expectancy	Number of years of life lost	Years of pension lost	Morbidity incidence	Number of deaths
Benzene	*leukaemia*	65	15	15	15	**385**	**342**
Trichlorethylene	*kidney cancer*	65	1.5	15	15	**54**	**20**
Radon	*lung cancer*	69	1.5	11	11	**2 388**	**2 074**
CO	*asphyxia*	33	0	47	20	**-**	**98**
Particulate matter	*lung cancer*	69	1.5	11	11	**2 388**	**2 074**
	cardiovascular	77	13	3	3	**10 006**	**10 006**
	COPD	79	12	1	1	**10 390**	**4 156**
Environmental tobacco smoke	*lung cancer*	69	1.5	11	11	**175**	**152**
	infarction	77	13	3	3	**1 331**	**510**
	stroke	80	11	0	0	**1 180**	**392**
	COPD	79	12	1	1	**150**	**60**

2.2.2. Economic impact assessment

From an economic point of view, indoor air pollution is a negative externality[2]. In this study, the impact of indoor air pollution on collective wellbeing is defined as the monetary value of the negative consequences of indoor air pollution, i.e. the amount of resources lost to society as a result of this pollution.

The socio-economic cost of indoor air pollutants consists of two types of costs, as detailed in the diagram below:

- The external cost, which measures the opportunity cost of resources allocated due to the existence of the indoor air pollution;
- the impact of the change in the balance of public finances caused by the presence of indoor air pollutants.

[2] Consequence for which no monetary compensation was originally planned in a transaction where one party is affected by the intentional or unintentional behaviour of the other.

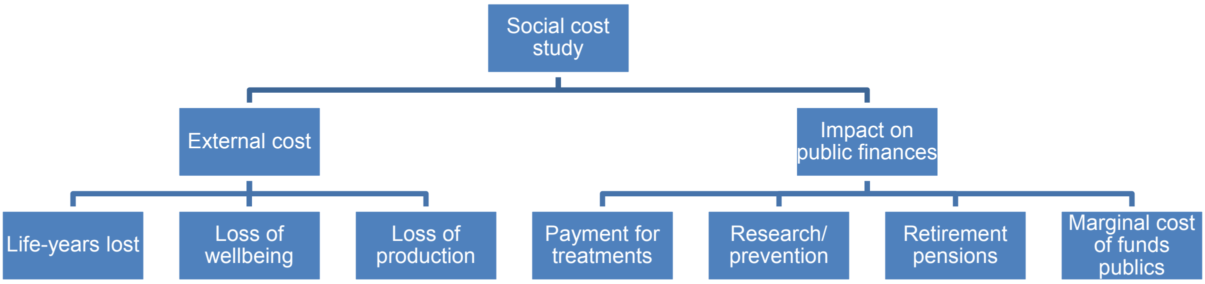

Figure 1: Tree diagram showing estimated costs in the context of the study of the socio-economic cost of indoor air pollution

Economic assessment of the external cost

The reference value of a life year is €115,000 according to the report by Quinet *et al.*[3] (2013). Moreover, the Lebègue report (2005) suggests using a rate of 4% in the adjustment calculations. These data were used in the calculations made subsequently.

The cost of a premature death is equal to the adjustment of the reference value for the number of life-years lost between the average age at death and the life expectancy at birth, established at 80 years in 2004 (Pison 2005). The adjusted values are then multiplied by the number of deaths for a disease associated with exposure to a pollutant, in order to obtain the total cost of the deaths for this disease. The overall cost of mortality is the sum of the costs for each disease.

Exposure to indoor air pollutants may result in the onset of diseases that therefore entail a reduction in the quality of life. An economic cost can therefore be estimated in terms of loss of quality of life calculated by the WHO (2004) depending on the disease. The adjustment extends over the period of survival in the disease condition. Each adjusted flow was then multiplied by the number of incident cases for a disease associated with exposure to a pollutant, in order to obtain the total cost of the loss of quality of life for this disease. The overall cost of the loss of quality of life is the sum of the costs for each disease.

In order to estimate loss of production, two situations were identified: if the disease was cancer, INCa data (2007) were used for the estimate. For other diseases, assumptions were made and are described in the study based on the authors' expertise.

Impact on wellbeing of the change in the balance of public finances

Payment for treatments represents the expenditure associated with the medical care of sick people. These costs were estimated using INCa data (2007) when the disease considered was cancer. In other cases, the information came from the literature on health economics or was based on an analysis of the PMSI hospital database.

[3] The purpose of the report on the "Socio-economic assessment of public investments" assigned by the General Commission for Strategy and Economic Foresight to Emile Quinet was to update and enrich the methodology for socio-economic assessment of public investments.

The expenditure related to research on indoor air pollution was calculated on the basis of a rough estimate of the number of public jobs allocated to this topic and the costs generated by their activities.

Lastly, the balance of expenditure may be subject to variations due to non-payment of all or part of retirement pensions due to early death. Therefore, the average amount of a retirement pension in 2004 was adjusted by 4% over the number of years of lost retirement, setting the average age at the start of retirement at 60 years and life expectancy at 80 years.

A weighting factor was associated with the impact on wellbeing of the change in the balance of public finances *via* the marginal cost of public funds.

2.3. Results

The estimates for the six pollutants selected for this study and corresponding to the different costs considered are shown in Table 2.

Table 2: Estimate of the economic impact associated with exposure to each of the six air pollutants studied (in millions of euros)

	Benzene	Trichlorethylene	Radon	CO	Particulate matter	Environmental tobacco smoke	Total
External cost							
Cost of mortality	-437	-26	-2 089	-237	-5 760	-322	-8 871
Cost of quality of life	-369	-7	-309	0	-7 350	-837	-8 872
Cost of production	-36	-2	-282	-72	-1 102	-85	-1 579
Total external cost	*-842*	*-35*	*-2 680*	*-309*	*-14 212*	*-1 244*	*-19 322*
Public finances							
Cost of treatment	-18	-4	-61	-3	-236	-37	-360
Cost of research	-	-	-	-	-	-	-11
Unpaid retirement pensions	10.2	0.6	49	4	136.5	8	+209
Total public finances	*-7.8*	*-3.4*	*-12*	*0.9*	*-99.5*	*-29*	*-163*
Effect of PF[1] on W[2]	*-9.4*	*-4*	*-14.4*	*1.1*	*-119.4*	*-35*	*-195*
Variation in W[2]	**-851**	**-39**	**-2 694**	**-308**	**-14 331**	**-1 279**	**-19 516**

1: Public finances; 2: Wellbeing

2.4. DISCUSSION

The study was based on various assumptions and methodological choices whose limitations are described below.

2.4.1. Health impact assessment

The health impact estimation method used was based on the principles of quantitative health risk assessment and health impact calculation. There are other approaches, such as those seeking to assess the burden of disease developed by the WHO. The WHO mentions the existence of two methods for calculating the burden of disease: a health event-based approach (the calculations are based on the incidence and/or prevalence of health events) and the exposure-based approach (the calculations are based on the exposure of the population). These studies estimate all the health impacts using the DALYs method. Apart from the issue of the relevance of these data at the scale of the French population[4], converting them into monetary terms would only enable the external costs of the studied diseases to be measured, i.e. just one of the two dimensions covered in the socio-economic cost approach.

Pollutant selection was mainly determined by the availability of the basic data needed for the health impact assessment (number of annual deaths, dose-response relationship, attributable share, etc.). The failure to include certain pollutants commonly found in the air of indoor environments and whose health effects are known may raise questions. The ranking that took place to identify priority pollutants in the indoor air of homes (Almeras, 2010; Logue *et al.,* 2011) mainly highlighted formaldehyde and acrolein, which nevertheless do not appear in this study due to the lack of published dose-response relationships for effects with a threshold mode of action. More generally, pollutants with a dose-threshold mode of action were ruled out due to the lack of an existing reference value for quantifying the health impact on the French population. Thus, the effects selected were mainly genotoxic carcinogenic effects with a non-threshold mode of action. Selection of the pollutants also ruled out agents such as asbestos due to the lack of representative measurement data on indoor environments for the general population. In general, the absence of nitrogen oxides (NO_x), many volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs) and biological agents (mainly mould) could be mentioned. A broadening of the number of indoor pollutants could at the very least include pollutants classified as a priority by the OQAI and ANSES, for which IAQGs were recently, or should soon be, established.
In addition, the study proceeded substance by substance and did not take into account the possible effects of co-exposures. A single effect or a part of the effects was considered for each pollutant, because there is no dose-response relationship, at least none that have been published, for all the associated effects.
Failing to take into account all the effects that may occur subsequent to exposure to a given pollutant ultimately leads to the cost of the health impacts being underestimated.
The mechanism of action, whether or not carcinogenic, may possibly result in cumulative exposure at levels that differ between the indoor and outdoor environments. For this exercise, the assumption adopted was development of a disease related only to exposure in indoor environments in proportion to the time spent in these environments.
Lastly, the health impact calculations were performed for one year only, considering 2004 as the base year. When no data were available for this year, as was the case, for example, with

[4] Report by Inserm-ORS Ile de France *"Peut-on utiliser les AVAI pour décrire l'état de santé en France ?" ["Can DALYs be used to describe the state of health in France?"]*. 111 pages, July 2007.

the data on environmental tobacco smoke, it was assumed that the available information could be extrapolated. Moreover, in order to calculate the health impacts, the assumption of continuous exposure during previous years at the same concentration was made. Only the effects and ultimately the costs associated with long-term exposure were considered, and not those associated with short-term exposure.

- **Exposure calculations** were performed with only a median concentration in indoor air, without using the entire distribution of concentrations, as this is considered the best estimate of the situations encountered if extreme situations are excluded. The variability of the exposure of the French population according to housing was therefore not taken into account. In addition, because of a lack of data, pollution levels measured in housing (bedroom or living room) were equated to the concentrations in all indoor environments.
- **Calculating the ratio between the morbidity and mortality data** also has limitations. This is because the ratio is based on national sources and sometimes lacks precision. This is the case for cancer subtypes when no data are available, for example, acute non-lymphocytic leukaemias, and especially acute myeloid leukaemia. Moreover, the ratio does not take into account the variation in age or the nature of the pollutant, which can affect the duration of the cancer. Finally, there is uncertainty about the average age at death, at the beginning of the disease, or life expectancy following development of the disease, since these data were not established specifically for diseases related to exposure to the studied pollutants.
- **Other issues can be highlighted that relate more specifically to the health impacts for each pollutant**.

  Regarding benzene, some authors discussed the form of the exposure-risk relationship between benzene exposure and the onset of leukaemia. For this study, the assumption of linear extrapolation to the origin, originally used by the WHO, was adopted.

  Regarding trichlorethylene, only the development of renal cell carcinomas was selected. The inclusion of other types of cancer should be discussed; for instance, the IARC concludes there is a limited level of evidence in favour of an association between exposure to trichlorethylene and the development of liver cancer and non-Hodgkin lymphoma.

  Regarding particulate matter, many assumptions were made, in particular that the effects associated with urban particulate matter were analogous to those with indoor air particles, through the use of risk-exposure relationships established for ambient air between particles defined as indicators of urban pollution and health indicators (morbidity/mortality). The relationships established were indeed based on changes in measurements of PM whose measurement corresponds to levels at urban-background stations. However, the population's exposure to particles results from their time spent in both indoor and outdoor environments. Thus, the results of studies on the health impact due to pollution of ambient air established in France, by the InVS[5] in particular, should by no means be added to the estimates offered by this exercise, to avoid double counting of deaths. Moreover, only the average estimate was used to calculate cost. However, the confidence interval [5590; 28,630] for the number of deaths from "all causes" (excluding violent deaths) (>30 years) related to particulate matter emphasises the uncertainty of the results. A proportion of the deaths from "all causes" is unexplained, namely the difference between the estimated number of deaths from "all causes" and the deaths due to cardiovascular disease and lung cancer. It seems reasonable, albeit still hypothetical, to

[5] French Institute for Public Health Surveillance

assume that these are respiratory diseases. To calculate the incidence, establish the average age at death and carry out the different cost calculations, these respiratory deaths were equated in a simplified manner to the consequences of COPD because of the availability of data for this disease. Furthermore, in order to calculate the incidence of cardiovascular diseases, a strong hypothesis was adopted whereby the incidence of these diseases is equal to the number of deaths, in order to be able to complete the calculations.

Regarding environmental tobacco smoke, the most recent data were used, from the 2006 *"Lifting the smokescreen"* report, analysed by Hill in 2011, despite their still being accompanied by much uncertainty. The estimates were made for 2002 and it was considered that they could be extrapolated to 2004, a date prior to the publication of the decree in the *Official Journal* of Thursday, 16 November 2006 laying down the conditions of application of the ban on smoking in public places. The authors estimated 1114 cases of mortality, of which 107 deaths were work-related, which may lead to an overestimation compared to the current situation. However, the number of deaths only concerns four risks (infarction, stroke, lung cancer, chronic respiratory diseases) and only applies to the adult population.

2.4.2. Economic impact assessment

- **The reference value of a life-year lost was adjusted,** and weighted or not depending on the nature of the cost to be estimated. This calculation method has several limitations. First, it is based on a value of €115,000 for a life year, given in the report by Quinet *et al.* (2013). This estimate is derived from a calculation whose exploratory approach was stressed by the report authors and which is not specific to indoor air pollution. The adjustments performed in this study were based on a single rate of 4% (Lebègue *et al., 2005).* The report by Quinet *et al.* (2013) underlines the relevance of using differentiated adjustment rates depending in particular on the time horizon considered or the nature of the morbid consequences of a disease.

- **Calculating the cost of morbidity differs from that of mortality by a weighting of the loss of quality of life.** These factors were based on assessments using scores sometimes calling on a subjective appreciation by the individuals concerned. Moreover, these data are not specific to France, which may mean that they vary according to the quality of healthcare system, for example.

  More generally, it is the actual estimation method using a reference value that can cause uncertainty. Indeed, there are other possible approaches such as contingent valuation, personal protection, hedonic pricing, or market cost. A comparison was made with the approach developed in the Aphekom study (Declercq, 2012) as regards exposure to particulate matter.

- **The second source of uncertainty arises not from the methods used but the assumptions adopted, especially regarding the different unit costs.** Several costs were estimated based on the assumptions of the project team (research costs, loss of production). However, the assumptions made have little impact in view of the low weight of these various costs in the overall cost.

- **Assumptions were also made due to a lack of data associated with each pollutant.** As an illustration, the monetary value of the elements making up the costs of treatment caused by **CO poisoning** was estimated ex nihilo*.* These assumptions are very approximate and are based on a summary representation of the degree of invalidation caused by the disease.

- **Loss of production** related to cancer was determined from INCa data (2007). In this case, using these data reveals several limitations. It was assumed that the exposure profile and individuals' responses to developing cancer are homogeneous. However, the exposures inducing these cancers can have significant spatial fluctuations; for instance **radon** is very present in Brittany, Franche-Comté, the Massif Central, and in Corsica. The socio-economic levels of these regions may vary with respect to each other and to the rest of the country. Therefore, the average production losses per individual are also likely to vary. Lastly, the loss of production may also be due to loss of productivity on the job due to deteriorated health. This point was not considered, with production losses in this case being limited to absenteeism.

3. Agency conclusions and recommendations

The aim of the study of the socio-economic cost of indoor air pollution in France was to test a method of assessing the health impact and economic impact through an approach that would assist the risk manager. This was an exploratory approach that sought to estimate the costs per year attributable to exposure to six indoor air pollutants. According to the method developed, the cost to the community would be around 19 billion euros for one year. Although the results are more illustrative than definitive because of the assumptions and limitations identified, it appears that the costs associated with the health impact of exposure to particles represent a major part of the overall cost.

From a methodological point of view, it seems difficult to compare these results with those generated in the other rare studies of the economic costs of air pollution conducted elsewhere. Indeed, there are apparent differences in the choice of pollutant, the methods of calculating the health impact, and in the assessment methods.

This exploratory study, once it has undergone further analysis, could be used to compare the socio-economic cost of exposure to indoor air pollutants with that of other health risk situations, such as consumption of tobacco products and alcohol, or traffic accidents.

In the short term, ANSES proposes:

- adopting a probabilistic approach that takes into account the variability and uncertainty of the data by combining this approach with a sensitivity analysis to estimate the influence of health and economic parameters in the calculation of socio-economic cost,
- initiating a debate on effects with a threshold-dose mode of action, with a view to assessing the external cost; and beyond this establishing dose-response relationships for all effects with a mode of action with or without a threshold dose for a substance, in order to extend the approach to other pollutants,
- conducting a comparative and critical analysis of the method used for this study with other methods proposed in the literature that focus on disease or exposure inputs with other health indicators (DALY/QALY),
- assessing the feasibility of a comparison of the costs related to various environmental pollutants with other risks such as those associated with active smoking and alcohol consumption.

In the longer term:

- testing the feasibility of an approach based on the sources of pollutants (furniture products, cleaning products, cooking activities, etc.),
- making economic estimates using different methods on a like-for-like cost basis, in order to conduct a sensitivity study with respect to the economic methodology.

BIBLIOGRAPHY

Alméras, C. (2010) Hiérarchisation sanitaire des polluants de l'environnement intérieur: mise à jour pour le cas des logements et extrapolation à d'autres environnements intérieurs. Observatoire de la qualité de l'air intérieur, Rapport n°ESE/Santé – 2010-095: 111 p.

CARB (2005) Report on indoor air pollution in California. US-California: 363 p.

Catelinois, O., Rogel, A., Laurier, D., Billon, S., Hémon, D., Verger, P., Tirmarche, M. (2007) Evaluation de l'impact sanitaire de l'exposition domestique au radon en France. Bulletin épidémiologique hebdomadaire. Numéro thématique – Impact sanitaire du radon domestique: de la connaissance à l'action, (18-19): 155-158.

Declercq, C., Pascal, M., Chanel, O., Corso, M., Ung, A., Pascal, L., Blanchard, M., Larrieu, S., Medina S. (2002) Impact sanitaire de la pollution atmosphérique dans neuf villes françaises - Résultats du projet Aphekom. Aphekom- InVS: 36 p.

Hill, C. (2011) Les effets sur la santé du tabagisme passif. Bulletin Epidémiologique Hebdomadaire n°20-21.

INCa (2007) Analyse économique des coûts du cancer en France. INCa: 146 p.

Jamrozik K. (2006) An estimate of deaths attributable to passive smoking in Europe. In: Smoke free Partnership. Lifting the smokescreen: 10 reasons for a smoke free Europe. http://www.ersj.eu/ : 17–41.

Lebègue, D., Hirtzman, P., Baumstark, L. (2005) Le prix du temps et la décision publique. Commissariat Général du Plan: 96 p.

Logue, J.M., Price, P.N., Sherman, M.H., Singer, B.C. (2012) A method to estimate the chronic health impact of air pollutants in US residences. Environmental health perspectives, 120(2): 216-222

WHO (2004) Global burden of disease 2004 update: disability weights for diseases and conditions. WHO: 9 p.
http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf

Pison, G, (2005). La France 2004: l'espérance de vie franchit le seuil de 80 ans. Population et Sociétés 410:1-4.

Pope III, C.A., Burnett, R.T., Thun, M.J., Calle, E.E., Krewski, D., Ito K., Thurston, G. D., (2002) Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution, Journal of the American Medical Association 287(9): 1132-1141.

Quinet, E., Baumstark, L., Bonnet, J., Croq, A,. Ducos, G., Meunier, D,. Rigard-Cerison, A,. Roquigny, Q, (2013) L'évaluation socio-économique des investissements publics. Commissariat Général à la Stratégie et à la Prospective: 352 p.