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Health impact of noise in the Paris agglomeration: assessment of healthy life years lost

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ABSTRACT

Many studies have shown that environmental noise exposures are related to non-auditory effects such as sleep disturbance, annoyance and cardiovascular diseases. The Regional Health Observatory and Bruitparif applied WHO methodology in order to quantify impacts of environmental noise on the health of the population in the Paris metropolitan area, in terms of DALYs (disability-adjusted life-years).
Health and noise exposure (coming from the strategic noise maps) data were aggregated at the “commune” (French counties) level. Our evaluation showed that around 66,000 healthy life years were lost every year in the Paris agglomeration due to noise exposure. The main health outcomes were sleep disturbance (nearly two thirds of the years lost) and annoyance.
Traffic noise had the greatest health impact (about 87% of the DALYs loss). Health impacts related to aircraft noise were much lower (4% of the DALYs loss), but they should be taken cautiously, as the use of the Lden indicator appears inaccurate to account for the event nature of aircraft noise.
This assessment gives a minimum approach of the health impact of noise in the Paris agglomeration and points that noise is a main public health interest. The results of this study will be presented.

1. CONTEXT AND OBJECTIVE

1.1 Noise, a major nuisance in Ile-de-France

Transport, industry, work, neighbourhood: there are many noise sources, especially in highly urbanised areas such as Ile-de-France. The population is subjected permanently to ambient noise exposure and, due to the extent of the urban fabric, it is difficult to avoid it. A study on the perceptions of the environment and its effects on health has shown that nearly three in four Ile-de-France inhabitants declare they are annoyed by noise at home; and one in four is annoyed often or permanently [1]. Noise ranks among the major nuisances felt by Ile-de-France inhabitants in their daily lives.

However, noise is above all perceived by Ile-de-France inhabitants as a local problem of quality of life before being a matter of health concern. Even though two thirds of Ile-de-France inhabitants perceive the health risk related to noise as rather high, the health concern they declare for other nuisances, like asbestos or air pollution, is clearly higher [1]. And yet there are many health effects of ambient noise.

1.2 From epidemiological studies to health impact assessment

The exposure to ambient noise, in particular in hyper-agglomerated areas, is a true public health stake. In order to guide public action in terms of ambient noise abatement, quantification methods of health risk have been developed in order to assess the health impact attributable to this exposure. The principle of this method, based especially on the knowledge of the exposure-response relation between a noise source and a health outcome, as well as the distribution of the noise exposure of the population, helps determine the number of cases attributable (for each outcome) to noise exposure within this population.

The World Health Organisation, in an international study coordinated by the WHO Regional Office for Europe and supported by the European Commission's Joint Research Centre (JRC) [2], has assessed at the European level, for each recognised health effect of noise (sleep disturbance, ischaemic heart disease, cognitive impairment of children, tinnitus and annoyance), the burden of disease with the quantitative indicator “disability-adjusted life-years” (DALYs). This study relies on the noise exposure data produced for the implementation of the 2002/49/EC European Noise Directive (END) at the scale of agglomerations or Member States, as they were available at the beginning of 2011 on the EEA (European Environment Agency) website.

It has then been estimated that at least one million healthy life years are lost every year in western Europe from transportation infrastructure noise:
- 61,000 years due to ischaemic heart disease,
- 45,000 years due to cognitive impairment of children,
- 903,000 years due to sleep disturbance,
- 22,000 years due to tinnitus,
- 587,000 years due to annoyance.

This work highlights the importance of this public health problem and provides technical support for quantitative risk assessment of environmental noise for the implementation of environmental and public health policies.

This method has been applied to the Paris agglomeration to calculate the burden of disease from environmental noise, using the data available at the town level (for both noise exposure and health indicators). This work has been conducted jointly by the Regional Health Observatory in Ile-de-France (ORS Ile-de-France) and Bruitparif (Noise observatory in Ile-de-France), with the support and expertise of Dr Rokho KIM from WHO.

2. Presentation of the WHO method

WHO relies on a corpus of epidemiological studies conducted by various research teams to assess the health risks of environmental noise and suggest a method to quantify the health impact of the different environmental noise sources through an estimation of the number of disability-adjusted life-years. This estimation is calculated for each health end-point using the following information and data:
- the number of cases in the population (incidence and prevalence) for each health end-point;
- the distribution of the exposure to the different environmental noise sources within the population;
- the known exposure-response relations for each health end-point and each noise source;
- the disability weight (DW) for each health end-point.

2.1 Health indicators selected

After examining the various studies available showing relations between noise and health, WHO has selected the following health outcomes:
- cardiovascular diseases,
- sleep disturbance,
- annoyance,
- cognitive impairment of children,
- tinnitus.

The noise sources taken into account in the estimation of DALYs related to environmental noise depend on the health outcome to characterise and the availability of exposure data. According to the outcome, the following noise sources have been considered: road noise, rail noise and air noise.

It is to be noted that the exposure data available are not sufficient to calculate the burden of disease from noise for cognitive impairment of children in the Paris agglomeration. Indeed, the distribution of noise exposure within the population aged 9 to 17 would have to be known, which is currently not the case. The method will therefore not be detailed for this indicator.

2.2 Noise exposure indicators

The noise exposure data used in the WHO study come from the statistical results required by the 2002/49/EC END strategic noise maps and transmitted by every Member State. These maps have been made for the regulatory indicators Lden and Lnight defined by the directive.

2.3 The relations chosen between exposure to a noise source and a health outcome

The exposure-response relations derive from the results of epidemiological studies. WHO [2] has selected an exposure-response relation, when available, for each health outcome chosen in relation with the different noise sources as presented below. For annoyance and sleep disturbance, the relation gives a direct estimation of the percentage of people affected according to the exposure level (equations presented below), whereas for myocardial infarction, the relation provides a relative risk. For tinnitus, there is no exposure-risk relation. However an estimation of the overall fraction attributable to environmental noise is suggested.

2.3.1 Relations selected for annoyance

Annoyance is the most widely accepted noise-related effect. Annoyance is usually assessed with questionnaires directly sent to the population. Standardised questionnaires have been developed in order to represent various degrees of annoyance. Dose-response relations between the exposure to a noise source and annoyance have been derived from them. The ones chosen for the WHO study come from a publication of the European Commission [3] that determines the percentage of the population highly annoyed by noise according to the sound level they are exposed to. The percentage of highly annoyed people (%HA) is estimated for each noise source with the following equations:

Road noise:

$$\%HA = 9.868 * 10^{-4}(L_{den} - 42)^3 - 1.436 * 10^{-2}(L_{den} - 42)^2 + 0.5118(L_{den} - 42)$$

Rail noise:

$$\%HA = 7.239 * 10^{-4}(L_{den} - 42)^3 - 7.851 * 10^{-3}(L_{den} - 42)^2 + 0.1695(L_{den} - 42)$$

Air noise:

$$\%HA = -9.199 * 10^{-5}(L_{den} - 42)^3 + 3.932 * 10^{-2}(L_{den} - 42)^2 + 0.2939(L_{den} - 42)$$

2.3.2 Relations selected for sleep disturbance

Sleep disturbance is one of the complaints most often mentioned by exposed populations. This disturbance can be approached by physiological measurements, however, in epidemiological studies, they are often collected by questionnaire. Scales have also been developed in order to represent various degrees of disturbance. Dose-response relations have then been developed, taking nightly exposures into account. The percentage of the population likely to have significant sleep disturbance related to noise exposure (%HSD Highly Sleep-Disturbed) is estimated with the following equations, based on the works of Miedema & al. [4]:

Road noise:

$$\%\mathrm{HSD} = 20.8 - 1.05(\mathrm{L_{night}}) + 0.01486(\mathrm{L_{night}})^2$$

Rail noise:

$$\%\mathrm{HSD} = 11.3 - 0.55(\mathrm{L_{night}}) + 0.00759(\mathrm{L_{night}})^2$$

Air noise:

$$\%\mathrm{HSD} = 18.147 - 0.956(\mathrm{L_{night}}) + 0.01482(\mathrm{L_{night}})^2$$

2.3.3 Relation selected for myocardial infarction

The epidemiological studies conducted in the last few years have shown an increase in the risk of ischaemic heart disease and more specifically myocardial infarction in relation with road noise exposure. There is currently less evidence for air traffic noise. Very few studies have been conducted on the cardiovascular effects of other environmental noise sources such as rail noise, for example. WHO has derived an exposure-risk relation from the incidence of myocardial infarction from the results of epidemiological studies selected according to the criteria detailed above. The Odds Ratio (OR), which can be interpreted as relative risk (RR), is expressed with the following equation:

$$OR = 1.63 - 0.000613 * (L_{day,16h})^2 + 0.00000736 * (L_{day,16h})^3$$

The acoustic indicator (Lday,16h) used in this equation, not required by the END, is not always available. The approximation advised by WHO to assess the Lday,16h indicator related to road noise is to use the Lden indicator and to consider that:

$$L_{den} = L_{day,16h} + 2dB$$

The relative risk (RR) is then calculated for each category of noise exposure.

Table 1: relative risk for myocardial infarction for each category of noise exposure

Category of noise exposure (Lden)	<55	55-59	60-64	65-69	70-74	>75
Odds Ratio	1	1	1.015	1.067	1.161	1.302

2.3.4 Tinnitus

Chronic tinnitus is a subjective noise, heard constantly, day and night, “in the ear” or “in the head,” without any outside sound stimulus. It can be the symptom of a pathology of the hearing system or the aftermath of a traumatic accident. It often appears after an acoustic or a barometric trauma. Usually, the etiology of tinnitus is not clearly identified. However, tinnitus very often appears simultaneously to a hearing loss. It can correspond to a noise induced by a hearing loss or directly induced by noise exposure. Even though the understanding of this physiopathology is limited, there is no doubt that chronic noise exposure can cause disabling tinnitus. The hearing loss is not supposed to occur for noise exposure to LAeq 8h levels below 75 dB(A), even for extended noise exposure at work. Likewise, noise exposure to LAeq 24h levels below 70 dB(A) should not cause hearing troubles for the large majority of the population, even after a lifetime of exposure. In some urban environments, road traffic noise sometimes exceeds a level of 85 dB(A). Environmental noise can therefore have a potential incidence not negligible for the appearance of tinnitus. Due to the limited number of available studies, it has not been possible to develop an exposure-response relation.

Most studies examined by WHO do not focus directly on the relation between the prevalence of tinnitus in the studied population and its potential causes. The rare studies that tackle this topic do not deal specifically with environmental noise as a causal factor. In addition, there is no particular clinical specificity for tinnitus induced by environmental noise compared with other potential causes. For lack of exposure-risk relation, the relative fraction of tinnitus related to environmental noise has been estimated by an expert consensus.

2.4 Disability weights chosen

The notion of disability expresses a more or less important degradation of the health state, quantified by the disability weight (DW). For each health outcome, the DW can vary from 0 (non-degraded health state) to 1 (death). It usually comes from expert opinions gathered by WHO. Several DW values can sometimes be suggested such as presented in the table 2 (the value selected in the WHO calculation is bolded).

Table 2: Proposals for disability weights (DW)

Disability weight	DWinf	**DW**	DWsup
Annoyance	0.01	**0.02**	0.12
Sleep disturbance	0.04	**0.07**	0.10
Myocardial infarction		**0.405**	
Ischaemic heart disease and hypertension		**0.350**	
Mild tinnitus		**0.01**	
Moderate to severe tinnitus		**0.11**	

For annoyance, while the number of studies dedicated to the determination of the DW is relatively limited, WHO suggests the value DW = 0.02 with a high range of uncertainty going from 0.01 to 0.12. The 0.02 value leads to a “conservative” approach, guided by the will to rather underestimate the burden of disease.

Based on an exhaustive study of several research works by the WHO expert panel, the DW related to sleep disturbance was set at 0.07 in the calculation of DALYs. The value selected takes into account DW statistical distributions observed in the various research works studied, the variations of which span a range of uncertainty between 0.04 and 0.10.

Various DW values are used in WHO reports of myocardial infarction risk assessment. The DW value selected by WHO is 0.405 for acute myocardial infarction[1] [2]. In the literature, values around 0.350 are reported for ischaemic heart disease and hypertension.

Regarding the determination of the DW related to tinnitus, the WHO expert panel studied several approaches. The approach selected was based on the concept of “affecting ability to lead a normal life.” Two DW values were suggested for different severity levels of the disease. According to the stage of the disease, the DW related to each stage of tinnitus varies from 0.01 (mild stage) to 0.11 (moderate and severe stages). These figures represent an increased sensitivity to the effects of environmental noise for the most severely affected people.

2.5 Calculation of the burden of disease

The overall burden of disease from noise can be expressed with the synthetic indicator DALYs (disability-adjusted life-years). For a given civil year, DALYs represent the number of healthy life years lost by a population on a given territory. It is the sum of years of life lost (YLL) due to premature death and healthy years lost due to disability (YLD).

$$DALY = YLL + YLD$$

The WHO method estimates this indicator for each health outcome of noise exposure selected. Premature death only concerns infarctions, so the number of years of life list due to premature death is only calculated for this health outcome. The other outcomes are only expressed in terms of healthy years lost to disability.

2.5.1 Calculation of healthy years lost to disability (YLD)

This calculation is done with the following equation:

$$YLD = I * DW * D$$

where I is the number of cases attributable to noise within the population (for each health outcome considered), DW is the disability weight and D an average duration of disability expressed in years. For the calculations, the duration was considered equal to 1 as the assessment corresponds to a civil year. The number of attributable cases (I) is obtained by applying the attributable fraction to the size of the population.

2.5.2 Calculation of years of life lost (YLL) due to premature death

The YLL indicator is calculated with the following equation:

$$YLL = \left(\sum_{death} L \right) * PAF$$

where L is the life expectancy at the time of death, and PAF (population attributable fraction), the fraction of deaths that occur after a myocardial infarction attributable to noise. The PAF is calculated from the percentage of population exposed and the exposure-response relation with the following equation:

$$PAF = \frac{(\sum_i P_i RR_i) - 1}{\sum_i P_i RR_i}$$

where i is the noise exposure category, Pi the percentage of population in the i category, and RRi the relative risk related to the i category.

2.5.3 Calculation of DALYs for tinnitus

The following equation sums up the method suggested by WHO to estimate the DALYs indicator related to tinnitus.

$$DALYs = n_{pop \geq 15\, years\, old} \times \alpha \times \sum_{i=1}^{3} p_i \times DW_i$$

where:

npop≥15 years old represents the population aged 15 and more on the whole territory studied,

α represents the fraction attributable to environmental noise,

pi represents the prevalence rate of tinnitus for 3 stages of the disease (i = {1, 2, 3},

DWi represents the disability weight for 3 stages of the disease (i = {1, 2, 3},

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[1] *WHO epidemiological subregion in Europe: Andorra, Austria, Belgium, Croatia, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.*

[2] *Mathers CD et al. Global burden of disease in 2002: data sources, methods and results. Geneva, World Health Organization, 2003 (Global Programme on Evidence for Health Policy Discussion Paper No. 54) http://www.who.int/healthinfo/paper54.pdf, accessed 28 August 2006).*

i = 1: mild stage of the disease, i = 2: moderate stage, i = 3: severe stage.

3. Application of the method to the Paris agglomeration

3.1 Delimitation of the study area

At the scale of the Ile-de-France region, the study has been limited to the territory of the Paris agglomeration[3]. Indeed, currently there are only partial data on the noise exposure of the populations outside this territory, where only data in proximity to major transportation infrastructures are available (roads with more than 6 million vehicles a year, railways with more 60,000 trains a year). The territory of the Paris agglomeration counts 9,644,507 inhabitants (INSEE 1999).

3.2 Noise exposure data

In order to apply the method to the Paris agglomeration, Bruitparif has exploited the noise exposure statistics published by the towns and intercommunalities in charge of the implementation of the 2002/49/EC directive at the scale of the Paris agglomeration. These data are available for nearly 90% of the population of the Paris agglomeration. For the towns and intercommunalities where the maps have not been made or have not yet been published, Bruitparif has used the exposure data provided by the major infrastructure maps produced by the State services. These are data in proximity to the major transportation infrastructures (roads with more than 6 million vehicles a year, railways with more 60,000 trains a year).

3.2.1 Estimation of the exposed population regarding annoyance

For every town, the equations described at §2.3.1 require data on the distribution of the population according to their exposure level assessed with the Lden indicator. The data available are the number of inhabitants by 5-dB(A) categories, from 55 dB(A).

In order to calculate the percentages of highly annoyed people for each category of noise, the Lden value corresponding to the mid-level of each category has been selected, i.e. the following values: 57.5 dB(A) / 62.5 dB(A) / 67.5 dB(A) / 72.5 dB(A). Beyond 75 dB(A), in order not to overestimate the number of highly annoyed people, the value 72.5 dB(A) has been applied in order to keep the rate of annoyed people similar to the one of the 70-75 dB(A) category.

For annoyance, the application of the DALYs method requires quantifying the population exposed to Lden levels below 55 dB(A). As the noise exposure data are not available for these values, Bruitparif has estimated the affected population of the Paris agglomeration from the following hypotheses:

- for road noise exposure, the population not allocated to the different Lden categories above 55 dB(A) has been entirely allocated to the category < 55 dB(A);
- for rail noise exposure, the percentage of the population in the category < 55 dB(A) is supposed to be the same as the one listed in the 55-59 dB(A) category;
- for air noise exposure, the population not allocated to the Lden categories above 55 dB(A) has been entirely allocated to the category below 55 dB(A) for the towns impacted by air noise4;
- for the three noise sources considered (road, rail and air), for the population exposed to Lden levels below 55 dB(A), the 48 dB(A) value has been selected.

3.2.2 Estimation of the exposed population regarding sleep disturbance

For every town, the equations described at §2.3.2 require data on the distribution of the population according to their exposure level assessed with the Lnight indicator. The data available are the number of inhabitants by 5 dB(A) categories, from 50 dB(A).

In order to calculate the percentages of highly disturbed people for each category of noise, the Lnight value corresponding to the mid-level of each category has been selected, i.e. the following values: 52.5 dB(A) / 57.5 dB(A) / 62.5 dB(A) / 67.5 dB(A). Beyond 70 dB(A), the value 72.5 dB(A) has been applied.

For sleep disturbance, the application of the method to estimate DALYs related to noise requires quantifying the population exposed to Lnight levels in the 45-49 dB(A) category. As the noise exposure data are not available for these values, WHO has stated as a hypothesis that the percentage of

[3] *The INSEE definition of the notion of urban unit or agglomeration is based on the continuity of buildings and the number of inhabitants. An urban unit is a town or a group of towns with a continuous built area (no gap of more than 200 metres between two buildings) and with at least 2000 inhabitants.*

[4] *Towns listed in the Noise Annoyance Plans (PGS) and the Noise Exposure Plans (PEB) or part of the Sound Environment Curves (CES).*

the population in the 45-49 dB(A) category is the same as the one listed in the 50-54 dB(A) category. The value 47.5 dB(A) has been selected for the 45-49 dB(A) category.

3.2.3 Estimation of the exposed population regarding myocardial infarction

For every town, the number of people exposed to the following noise categories (Lden) has been estimated: < 55 dB(A); 55-59 dB(A); 60-64 dB(A); 65-69 dB(A); 70-74 dB(A); > 75 dB(A).

3.2.4 Estimation of the exposed population regarding tinnitus

Under the aegis of WHO, an expert consensus has estimated the fraction of tinnitus specifically attributable to environmental noise at 3%. This value is considered conservative, plausible and reasonable.

3.3 Health data

The indicators selected at the scale of the Paris agglomeration to calculate the burden of disease from noise are summed up in the table 3.

Table 3: indicators selected to calculate the burden of disease in Paris agglomeration

	Environmental noise		
	Road noise	Rail noise	Air noise
Annoyance	YLD	YLD	YLD
Sleep disturbance	YLD	YLD	YLD
Myocardial infarction	YLL / YLD	-	-
Tinnitus	YLD		

The distribution of the noise exposure of the population helps calculate directly the DALYs indicator for annoyance and for sleep disturbance. However, in order to determine the impact of noise on the number of myocardial infarction cases in the Paris agglomeration, some health data on the number of incident cases are necessary. Likewise, in order to determine the impact of noise on the appearance of tinnitus, some prevalence data are necessary.

3.3.1 Incidence of the appearance of myocardial infarction and number of deaths

As Ile-de-France does not have a monitoring network for this type of events (like a register for instance), the number of cases has been estimated from hospitalisation data from the Information System Medicalisation Programme (PMSI). Considering the information available in PMSI databases (especially the post code of residence of the patient, follow-up information on the patient, readmission) and the fact that non-fatal myocardial infarctions are almost systematically followed with hospitalisation, this source of data seems to be the most relevant. According to InVS, the use of PMSI data gives a good estimation of the myocardial infarction (IM) data compared with register data.

The number of incident[5] cases of myocardial infarction has been estimated for the year 2008 with the following process:

- selection of all the hospitalisations of patients residing in the Paris agglomeration bearing the mention IM (codes CIM-10 I21 to I23) on the main diagnosis of at least one medical unit summary (RUM);
- grouping of myocardial infarction episodes occurring in a 28-day interval into a single episode;
- elimination of the episodes leading to death;
- inventory of all these episodes by post code.

This way, 5196 cases of non-fatal myocardial infarctions have been found in the Paris agglomeration for 2008.

The mortality data have been provided by the Epidemiological centre on the medical causes of death (CépiDC) of the French national institute of health and medical research (Inserm). For the year 2008, 1807 deaths from myocardial infarction have been found in the Paris agglomeration.

3.3.2 Prevalence of tinnitus

There are no prevalence data of tinnitus for Ile-de-France. However, the works of Davis [5] and Hannaford [6] helped estimate the prevalence of tinnitus in the European population aged 15 and more, according to 3 stages of the disease:

- 3.4% of this population suffers from tinnitus at a mild stage,
- 1.2% at a moderate stage,
- 0.4% at a severe stage.

5 *Incidence is the number of new cases of a pathology observed within a population for a given time period.*

If this European rate is applied to the population of the Paris agglomeration, which amounts to considering that the population of the Paris agglomeration corresponds to the European average, it is possible to estimate the DALY indicator.

3.4 Calculation of the burden of disease from noise

The calculation is done for each health outcome. For more accurate results, the method described above has been applied to every town. The results have then been aggregated at the scale of the Paris agglomeration.

3.4.1 In terms of annoyance

The number of highly annoyed people and the number of related DALYs can be calculated for each noise source and for every town of the Paris agglomeration. The summary of the results obtained at the scale of the Paris agglomeration is presented in Table 4.

Table 4: Estimation of the DALYs lost due to annoyance related to environmental noise exposure in the Paris agglomeration.

Noise source	% of highly annoyed people	Number of highly annoyed people	DALYs lost		
			DW=0.01	**DW=0.02**	DW=0.12
Road	11.2%	1 075 430	10 754	**21 509**	129 052
Rail	0.9%	86 922	869	**1 738**	10 431
Air	1.1%	106 704	1 067	**2 134**	12 804
Total	**13.2%**	**1 269 056**	12 691	**25 381**	152 287

This calculation suggests that there are around 25,000 healthy life years lost due to annoyance related to noise within the Paris agglomeration. If 0.01 and 0.12 are taken as extreme values for the DW, the range of variation for DALYs goes between 12,000 and 153,000 years.

3.4.2 In terms of sleep disturbance

The summary of the results obtained at the scale of the Paris agglomeration is presented in Table 5.

Table 5: DALYs lost due to sleep disturbance related to noise exposure in the Paris agglomeration.

Noise source	% HSD	Number of HSD people	DALYs lost		
			DW=0.04	**DW=0.07**	DW=0.1
Road	5.3%	509 208	20 368	**35 645**	50 921
Rail	0.6%	54 341	2 174	**3 804**	5 434
Air	0.1%	9 480	379	**664**	948
Total	**5.9%**	**573 029**	22 921	**40 112**	57 303

3.4.3 In terms of myocardial infarction

The summary at the scale of the Paris agglomeration of the DALYs lost due to myocardial infarction related to road noise exposure is presented in Table 6.

Table 6: DALYs lost in the Paris agglomeration due to myocardial infarction related to environmental noise.

Noise source	PAF (average %)	Number of attributable non-fatal myocardial infarctions	Number of attributable deaths	DALYs		
				YLD **DW=0.405**	YLD DW=0.350	YLL
Road	3%	165	59	**67**	58	**778**

3.4.4 In terms of tinnitus

Table 7 presents the results of the estimation of healthy life years lost in the Paris agglomeration due to tinnitus related to environmental noise[6].

[6] *The calculations have been done based on the figures published by the INSEE for the Ile-de-France region from the 1999 population*

Table 7: Estimation of the DALYs lost in the Paris agglomeration.

Total population (1999)	Population aged 15 and more (1999)	Studied population with tinnitus		DW	Weight due to environmental noise	DALYs
9644507	7 828 653	Mild (3.4%)	269474	0.01	0.03	81
	(≈81.1%)	Mod. (1.2%)	93775	0.11	0.03	309
		Sev. (0.4%)	32023	0.11	0.03	106
		Total	395272			**496**

3.5 Summary

Tables 8 and 9 sum up the results of the impact of environmental noise on the various health outcomes studied. The values selected are the ones obtained with the DW used by WHO. In total, the estimation from the method implemented is around **66,000 healthy life years lost** every year in the Paris agglomeration. The main health outcome of environmental noise exposure is sleep disturbance, which represents on its own nearly two thirds of the years lost (DALYs). Annoyance is the second health outcome with more than **25,000 healthy years lost**.

Regarding the environmental noise sources, road noise is the main source of burden of disease. Indeed, with 58,000 DALYs, road noise represents on its own 87% of the estimated healthy life years lost in the Paris agglomeration.

Table 8: Summary of the burden of disease from environmental noise for each health outcome.

Health outcome	YLL	YLD	**DALYs**
Annoyance	0	25 381	**25 381**
Sleep disturbance	0	40 112	**40 112**
Infarction	778	67	**845**
Total	**778**	**65 560**	**66 338**

Table 9: Summary of the burden of disease from environmental noise for each environmental noise source.

Noise source	YLL	YLD	**DALYs**
Road	778	57 220	**57 998**
Rail	0	5 542	**5 542**
Air	0	2 798	**2 798**
Total	**778**	**65 560**	**66 338**

The health effect related to tinnitus needs to be added to this assessment. It represents around **500 healthy life years** lost in the Paris agglomeration, for a population aged 15 and more.

3.6 Uncertainties

There are uncertainties for every step of this method to assess the health impact. However, the choices made have been systematically guided by the will to minimise the health impact.

3.6.1 Uncertainties related to the data

The quality of the data is key, especially regarding the exposure estimations. For this work, the exposure estimations are based on the data provided with the implementation of the 2002/49/EC directive. The quality of these data varies from one town to the other. In order to minimise this variability factor, the results are expressed at the scale of the agglomeration in order to average the possible estimation errors. In addition, the exposed population is estimated by exclusively considering the noise levels on the facades of the buildings. So, the layout of the rooms, the presence or the absence of a quiet facade, or even the acoustic insulation performances are not taken into account. The time

census, for the population of the Paris agglomeration aged 15 and more (data available on the INSEE website - www.insee.fr).

spent at home and the exposures outside of home are not taken into account either. All of these elements are a significant limit to the accuracy of the estimations.

Finally, the population data mostly exploited date back to 1999 whereas some exposure data as well as some pathology prevalence data are more recent. These discrepancies also contribute to the uncertainty of these estimations.

3.6.2 Uncertainties related to the exposure-risk relations

These relations are expressed with a confidence interval which contains the “true” value (with a 95% probability). For calculations, for simplification purposes, the central value has been selected. For myocardial infarction risks, this interval covers the zero risk value; this estimation is considered non-significant. However, for analyses conducted on population subgroups with a higher exposure (duration of residence between 10 and 15 years), the estimated risks become significant and are increased. This strengthens the plausibility of the relation despite the statistical limits mentioned.

3.6.3 Choice of the disability weights

The choice of the disability weight has a strong influence on the results. This is why, considering the importance of this criterion and the difficulty in reaching an expert consensus for the choice of these values, especially regarding the subjectivity of some outcomes such as annoyance or sleep disturbance, the calculations have been done for several DW values.

3.6.4 Air pollution, a confounding factor

The individuals exposed to road noise are usually also exposed to air pollutants. For cardiovascular pathologies, epidemiological studies also show a relation between this outcome and air pollution. The question remains whether concurrent exposures to noise and air pollution have independent, additive or synergistic effects. Indeed, few epidemiological studies have focused on this question. However, cardiovascular pathologies have been demonstrated as an effect specific to noise in a working environment with exclusive noise exposure.

3.6.5 Limits of the Lden indicator to estimate the population’s exposure to air noise

In the WHO method to estimate DALYs from environmental noise, the relation between the exposure to transportation noise and the different health outcomes relies on the energetic indicator Lden. This acoustic indicator corresponds to an average exposure dose calculated over a 24-hour period with a corrective term of +5 dB(A) for the evening period (6 pm-10 pm) and +10 dB(A) for the night period (10 pm-6 am). If the Lden indicator is well adapted to continuous noise sources such as road traffic noise, it is however not sufficient to translate on its own the population’s exposure to noise sources showing an event aspect such as air traffic.

4. Conclusion

The results presented in this paper already give, from the data currently available, a first estimation of the burden of disease from environmental noise within the Paris agglomeration. The estimated health impact shows the significance of this public health problem with around **66,000 healthy life years lost**, hence the importance of noise action plans.

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