TECHNICAL REPORT

EFFECT OF NOISE ON PHYSICAL HEALTH RISK IN LONDON

REPORT ON PHASE 2 – ESTIMATES OF THE NUMBERS OF PEOPLE AT RISK

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ABSTRACT
Berry Environmental Ltd [BEL] was commissioned, in December 2007, by the Noise Strategy Team at the Greater London Authority [GLA] to;

- Provide guidance on the robustness of published cardiovascular risk factors arising from ambient/environmental noise, using the latest available World Health Organisation (WHO) reviews, and other reviews of evidence/criteria, and to suggest best estimates of the factors from the range of published values.
- Use derived factors to generate estimates of the numbers of people at cardiovascular and related health risk, from road and air traffic noise, in London, from available population exposure data.

BEL Technical Report 2008 -1 [Reference 1] covered the initial review phase of the project.

This present Report uses risk factors derived from the initial review phase, in the form of Exposure-response relationships, together with available population noise exposure data, to generate estimates of the numbers of people within the GLA area, at risk from Acute Myocardial Infarction AMI, and from Ischaemic Heart Disease IHD, from road and air traffic noise.

NOTE. This report is a revised and updated version of a report dated March 31 2008, which was withdrawn. The main changes relate to estimates of numbers of potential cases around London Heathrow and London City Airports

1. INTRODUCTION - AIMS ETC

Berry Environmental Ltd [BEL] was commissioned, in December 2007, by the Noise Strategy Team at the Greater London Authority [GLA] to;

- Provide guidance on the robustness of published cardiovascular risk factors arising from ambient/environmental noise, using the latest available World Health Organisation (WHO) reviews, and other reviews of evidence/criteria, and to suggest best estimates of the factors from the range of published values.
- Use derived factors to generate estimates of the numbers of people at cardiovascular and related health risk, from road and air traffic noise, in London, from available population exposure data.

For convenience, the full Brief is given at Annex 1 to this Report.

The stated Aims are;
"1. Briefly review and list the latest evidence and published policies and/or guidance (adopted or proposed) of WHO and public bodies or authorities in other countries on the link between noise and physiological health impacts, providing a view on the robustness of the risk factors they use or currently propose and suggest best estimates of the risk factors and probable margins of error, and summarising plausible causal pathways to assist in popular interpretation of estimates. As far as possible, this should apply a standard of evidence similar to that applied to equivalent risk factors for air quality impacts.
2. Apply the suggested risk factors to available London population noise exposure data derived from maps for road traffic noise, Heathrow and London City Airports to determine overall impacts.
3. Make summary comparisons between the best estimate risk factors and outcomes for two other health impacts from road traffic in London (e.g. air pollution impacts and road traffic accidents), to place the noise outcomes in context.
4. Clearly explain the methodology used to derive the risk factors and to apply these to the population exposure data to derive overall numbers of premature deaths, QALY/DALYS and any other outcomes analysed, so that the client can derive and apply revised factors in future as scientific understanding advances and/or new population exposure data become available. "

BEL Technical Report 2008 -1 [Reference 1] covered the initial review phase of the project.

This present Report uses risk factors derived from the initial review phase, in the form of Exposure-response relationships, together with available population noise exposure data, to generate estimates of the numbers of people within the GLA area, at risk from Acute Myocardial Infarction AMI, and from Ischaemic Heart Disease IHD, from road and air traffic noise.

The present Report is arranged in 7 further Sections;

- Section 2 outlines the general principles of the calculation method, and the general requirements for Input data.
- Section 3 summarises the selection of exposure-response relationships, based on the initial review phase of the project.
- Section 4 describes the input data on the occurrence of Cardiovascular diseases and how it was obtained.
- Section 5 describes the input data on the "Population Noise Exposure" within the GLA area, to Road Traffic Noise and Aircraft Noise.

- Section 6 sets out the results of the calculations for Road Traffic Noise, Aircraft Noise around London Heathrow Airport, and Aircraft Noise around London City Airport.
- Section 7 discusses the overall results and 8 provides conclusions.
- Section 9 lists the relevant reference documents.

Annex 1 gives the original Project Brief in full, for reference.

Annex 2 outlines a brief analysis of the effect of uncertainty in the Exposure-response relationship on the results of the calculations.

Annex 3 brings together assumptions made during the course of the calculations.

2. Principles of the calculation method and the general requirements for input data

2.1 Method

The calculation method used follows the same principles which were applied by Babisch in his calculations of the number of cases of Acute Myocardial infarction due to Road Traffic Noise in Germany, as published in his 2006 Report [Reference 2, see pages 57-60].

It should also be noted that the same calculations by Babisch appear in the 2005 WHO Report on "*Quantifying the burden of disease from environmental noise: Second technical meeting report*"
http://www.euro.who.int/Document/NOH/Noise_EDB_2nd_mtg.pdf

The calculation relies on having the following information:

1. An **exposure-response relationship** between the health effect [expressed as Relative Risk RR or Odds Ratio OR] and the noise exposure, and,

2. **Two sets of Input data** for a given population, for the same given year under consideration - data on the occurrence of cardiovascular disease, and data on the noise exposure of the population to the noise source in question.

   a. **Data on the occurrence of Cardiovascular disease**
   Our particular interest is in the total number of cases of Ischaemic Heart Disease IHD, and the number of cases of Acute Myocardial Infarction within the population of the GLA area. See Section 4 for details.

   b. **Data on Noise Exposure**
   This takes the form of a "distribution" of the percentage of the population exposed to different noise levels, normally in 5dB steps or categories. See Section 5 for details.

Following the conventional terminology in this topic [Reference 3], the number of people affected, either within a given Noise Exposure category, or in total, is known as the **Population Attributable Risk PAR.**

PAR is itself calculated by multiplying the **Population Attributable Risk percentage PAR%** by Nc, the total number of cases of AMI [or IHD] – as follows:

PAR = (PAR%/100) * Nc

PAR% is calculated from the Relative Risk RR at a given Noise level - which is itself derived from the Exposure-response relationship - together with the Percentage of the population exposed at that noise level Pe, from the following equation:

PAR% = [Pe/100 * (RR-1)] / [(Pe/100 * (RR-1) + 1)] * 100 [1]

[1] Strictly speaking, this formula applies to prospective risk. This is assumed to be the case in this Report, in which procedures used by Babisch, in a similar application, are being followed.

2.2 Implementation

A spreadsheet was produced using MSExcel software to implement the above formulae. This was designed to generate a series of Tables of the generic kind shown below (following the format used in the 2006 Babisch Report (Reference 2]):

NOISE SOURCE	**Relative risk** **OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year**
NOISE LEVEL dB				
55-59				
60-64				
65-69				
70-74				
≥ 75 dB				
SUM				

As a "quality control" check, the data given in Table 5, page 60 of the 2006 Babisch Report [Reference 2] were used as input to the spreadsheet. Identical results were obtained.

*[NOTE**:** In doing this check, it was noted that the numerical values of Relative Risk used by Babisch, in his Table 5, were those from the actual pooled data in his meta-analysis, rather than the values generated by the polynomial equation of best-fit.]*

3. Exposure-response relationships for Noise and Cardiovascular Effects

The Report on the initial "Review Phase" of this project [Reference 1] provided a detailed overview of previous published reviews of the topic of noise and Cardiovascular Effects, up to the year 2006. More recent studies involving Road Traffic Noise and Aircraft Noise were also identified and summarised.
Account was also taken of a recently issued Draft Chapter on Cardiovascular effects, by Dr Wolfgang Babisch and Dr Irene van Kamp - Version 2 Draft January 2008, for a new Report being prepared for the World Health Organisation [WHO] Working Group - Aircraft noise and health.
Evidence for such cardiovascular effects, and possible *"exposure-response relationships",* relating Noise levels to the effects, were reviewed.

Two main categories of cardiovascular effect were considered:

- Hypertension – Chronically elevated blood pressure,
- Acute Myocardial infarction [AMI] – Heart attack.

For **Hypertension**, it was noted that the recent WHO Draft Chapter had concluded that:

*"The general conclusion is that there is sufficient evidence for a positive relationship between aircraft noise and high blood pressure and the use of cardiovascular medication. However****, no single common exposure-response relationship can be established for the association between aircraft noise and cardiovascular risk due to methodological differences between studies and the lack of continuous or semi-continuous (multi-categorical) noise data. For the same reason no answer can be given regarding possible effect thresholds.***

For **Acute Myocardial Infarction AMI** it was noted that, for **Road Traffic Noise**, an *"exposure-response relationship*" had been proposed - based on a careful meta-analysis, using stringent criteria, of five analytic studies, that could be used for deriving the relationship between road traffic noise, expressed as $L_{day\ [0600-2200],}$ and the risk of Acute Myocardial infarction AMI. It was also noted that this relationship had been applied by Wolfgang Babisch to estimate the potential number of people at risk of cardiovascular effects from road traffic noise in Germany [Reference 2, pages 58-60].

For **Aircraft noise**, there have as yet been an insufficient number of high quality studies on which to base such an exposure-response relationship but it has been argued by Wolfgang Babisch, that the relationship developed for Road Traffic Noise should be used as an "approximation".

Thus, in his 2006 Review [Reference 2] he states:

"Regarding aircraft noise - and particularly the ongoing debate on night-flight restrictions in the vicinity of busy airports - ***no other alternative exists at present than to take the MI risk curves derived from road traffic noise studies as an approximation for aircraft noise.*** *Since aircraft noise acts on all sides of a building, i.e. different to road traffic noise, the suspicion exists that the effects induced by aircraft noise could be greater than those induced by road traffic (Babisch 2004a; Ortscheid and Wende 2000). This may be due to the lack of evasive possibilities within the home, and the greater annoyance reactions to aircraft noise, which are usually expressed in social surveys (Miedema and Vos 1998)."*

Whilst there might be equally strong arguments against such an approach, nevertheless, for the purposes of the present study and this Report, **the same basic exposure-response curve will be used for all calculations.**

This relationship, and the relevant equation, is shown below in Figure 1.

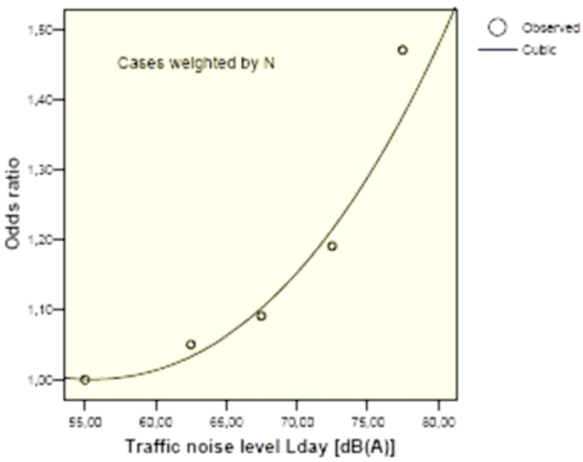

Figure 10. Polynomial curve fit (N-weighted data points) of the association between road traffic noise and incidence of myocardial infarction.

$OR = 1.629657 - 0.000613 \cdot Noise^2 + 0.000007356734623455 \cdot Noise^3$; $R^2 = 0.96$

(no significant linear term in the equation)

Figure 1. Exposure-response relationship used in Calculations [from Reference 2].

Subsequent to completion of the Report on the initial “Review Phase” [Reference 1], BEL were asked to include some additional calculations to estimate the potential number of people at risk of the broader category of cardiovascular diseases covered by the term Ischaemic Heart Disease IHD. As noted in Reference 1, Ischaemic heart disease includes clinical symptoms of angina pectoris (chest pain), myocardial infarction (heart muscle damage), or electrocardiogram (ECG) abnormalities. See also Section 4 of this Report, where details of the numbers of hospital admissions etc are provided.

It must be emphasised that, in extending the calculations to include this broader category of IHD, the assumption is being made that one can use the same exposure-response curve shown above. In his 2006 review report Babisch suggested that similar calculations could be made with respect to all ischaemic heart diseases (IHD) - using the same curve for the relative risk. He noted [page 65 of Reference 2] that:

“These health endpoints are similarly considered in the noise hypothesis (see reaction schema in Figure 1) (Babisch 2002; Passchier-Vermeer and Passchier 2000). It may be a reasonable assumption that the relative risks for these endpoints show a similar relationship across noise categories. In cross-sectional and prospective cohort studies, the relative risks found for these health endpoints did look similar, within the statistical boundaries of uncertainty (confidence intervals) (Babisch et al. 1993a) (Babisch et al. 1999). However, the severe and manifest event of a myocardial infarction can be most reliably assessed in studies (Bormann et al. 1990).”

Because of the assumptions which are made in extending the calculations to include this broader category of IHD, the calculations in this case were only made for Road Traffic Noise. Thus it was considered that the assumption that the same exposure-response curve could be used for AMI and for IHD could not reasonably be applied for estimating the number of cases of IHD due to aircraft noise.

4. Input data on the occurrence of cardiovascular diseases

The assistance of the London Health Observatory (LHO) was obtained, and data was extracted and provided on the number of people admitted to hospital[2] under the following International Classification of Diseases ICD codes:

Cardiovascular Disease (ICD10: I00 - I99)
Ischaemic Heart Disease (ICD10: I20 - I25)
Acute Myocardial Infarction (ICD10: I21 - I22)
Acute Myocardial Infarction (ICD10: I21)

NOTE: ICD Codes I21-I22 includes I21, which is acute myocardial infarction AMI, **and** I22, which is subsequent (recurrent) myocardial infarction.

Such data was obtained for the year 2001/2 and for 2005/6.

It was felt that Codes I21-I22 represented the closest "equivalent", which could be readily obtained, to the data used by Babisch on "occurrence", or numbers of "cases" of AMI.
It was also considered that this would provide a "worst-case" estimate of the potential number of cases.

The full data set is given in Table 1 below.

Table 1. Occurrence of Cardiovascular diseases in London, 2001 and 2006

	Persons	
Disease	**2001/02**	**2005/06**
Cardiovascular Disease (ICD10: I00 - I99)	77,489	86,943
Ischaemic Heart Disease (ICD10: I20 - I25)	27,550	28,791
Acute Myocardial Infarction (ICD10: I21 - I22)	5,991	6,313
Acute Myocardial Infarction (ICD10: I21)	5,482	5,716

NOTE: this information was provided by the LHO solely for the purposes of this Report from Hospital Episode Statistics (Department of Health) for 2001/02 and 2005/06, and must not be used without permission of the LHO.

Mortality

Information on numbers of deaths from AMI (ICD10: I21 - I22), and from Ischaemic Heart Disease (ICD10: I20 - I25), in London, was obtained from the website of the National Centre for Health Outcomes Development (NCHOD) www.nchod.nhs.uk.

The information on numbers of deaths is shown below in Table 2.

Table 2. Numbers of deaths from AMI and IHD

Year	Male deaths from AMI	Female deaths from AMI	Total AMI deaths [persons]
2001	2451	1886	4337
2006	1636	1290	2926
Year	Male deaths from IHD	Female deaths from IHD	Total IHD deaths
2006	4481	3347	7828

[2] i.e. persons admitted more than once for the same health problem only count as one.

5. Input data on the "population noise exposure" to road traffic noise and aircraft noise, within the GLA area

5.1 Road Traffic Noise

Information on the Percentage of the GLA population exposed to different levels of noise from Road Traffic was taken from the "population exposure analysis" in Reference 4.

NOTE - Data on the populations exposed to road traffic and aircraft noise have been obtained from Defra, but responsibility for the use of these data in this report remains with the author and not Defra.

This provides information for Major Roads, defined as *"roads within the Transport for London Road Network (TLRN) and motorways"*, as well as for *"all modelled roads"*, designated as All Roads. It should be noted that *"all modelled roads"* in the Defra London Road Traffic Noise Map means only those roads for which traffic data are available and excludes many small 'local' roads, such as within housing estates. However, in most cases, the noise levels from these roads will be much lower and are likely to be below the level (i.e. the 60-65 dB contour band) at which the cardiovascular risk factors (see Figure 1) are greater than 1.

This data, which makes use of 2001 Traffic flow and Census data etc, is given in Table 3 below, for $L_{day,\ 12h}$.

Because this was derived from Noise Mapping under the Environmental Noise Directive, the noise data relate to annual averages.

Table 3. Percentage of population exposed to different levels of Road Traffic Noise.

ALL ROADS

Noise level	**$L_{day,\ 12h}$**
< 50 dB	72.76 %
50 -55	
55 -60	7.19%
60 -65	7.82 %
65 -70	9.23 %
70 -75	2.91 %
> 75 dB	0.10 %

MAJOR ROADS

Noise level	**$L_{day,\ 12h}$**
< 50 dB	94.23 %
50 -55	
55 -60	1.99 %
60 -65	1.13 %
65 -70	1.43 %
70 -75	1.15 %
> 75 dB	0.07 %

5.2 Aircraft Noise

Information on the numbers in the GLA population exposed to different levels of noise from London Heathrow Airport, and London City Airport was obtained from Defra. Percentages of the population were then calculated from these data. See Table 4.

Because this was derived from Noise Mapping under the Environmental Noise Directive, the noise data relate to annual averages.

Although in this case the Noise mapping data is from 2006, the population census data is from 2001. Factoring up of the population data to 2006 estimates, based on population growth estimates for the boroughs concerned was considered, but the changes were relatively small and it was felt that any errors introduced by using 2001 data would be small compared with other uncertainties in the overall calculation.

Table 4. Numbers and Percentage of population exposed to different levels of Aircraft Noise, above 55 dB

London Heathrow Airport

	Noise Exposure Descriptor	
Noise level	$L_{day, 12h}$	
55-59 dB	268200	73.8%
60-64 dB	74400	20.5%
65-69 dB	18600	5.1%
70-74 dB	2100	0.6%
≥ 75 dB	0	0%

London City Airport

	Noise Exposure Descriptor	
Noise level	$L_{day, 12h}$	
55-59 dB	9500	86.4%
60-64 dB	1500	13.6%
65-69 dB	0	0%
70-74 dB	0	0%
≥ 75 dB	0	0%

6. Results of the calculations

6.1 Assumptions on Noise Exposure Descriptors

Noise exposure descriptors feature in the calculations presented in this Report in two distinct ways. Firstly we need to take into account the exposure descriptor used in the selected exposure-response curve, which, as noted above in Section 3 was $L_{day\ 0600\text{-}2200}$.

Secondly, there is the question of which noise exposure descriptor was actually used in reporting the population noise exposure data - the percentage of the population exposed to different noise levels - outlined in Section 5.

In using this available information for the purposes of the calculations, a number of assumptions have to be made about the “equivalences” between the various noise exposure descriptors, and these are described below. In essence, since the Babisch OR data and curve are in terms of $L_{day\ 0600\text{-}2200}$, but the Population exposure data are for other Descriptors, in particular $L_{day,\ 12h}$, we have to take the noise level values in the Population exposure tables and "convert" them to an equivalent $L_{day\ 0600\text{-}2200}$.

Road Traffic Noise

The meta-analysis conducted by Babisch, discussed above, used $L_{day\ 0600\text{-}2200}$ as the physical descriptor of Noise Exposure, based on the noise data available from the separate research studies which he had analysed.

For the purposes of this Report, the following approach was taken.

Firstly it was noted that, in the process of developing the London Noise Maps [Reference 4], the CRTN procedure was used to calculate $L_{10,18h}$, from which the "component parts" of L_{den} i.e. L_{eq}, 12h, 4h and 8h, and hence L_{den}, are calculated using empirical formulae produced by TRL (see Reference 6].

For a given $L_{10,18h}$ it is possible to determine the exact values for the L_{eq} components (and L_{den}) for the two classes of roads in the TRL method (motorways and all others).

Applying the TRL formulae [equations 1.7 to 1.9 and 1.11 to 1.13] in "Method 3" which was used in the Report on the London Noise Maps [Reference 4] gives the following results for values covering more or less the range of interest:

For a value of $L_{10,18h}$ = 65 dB: $L_{eq,\ 12h}$ = 63.2, $L_{eq,\ 16h}$ = 62.6 for normal roads and 63.8 / 63.6 for motorways.

For a value of $L_{10,18h}$ = 80 dB: $L_{eq,\ 12h}$ = 77.4, $L_{eq,\ 16h}$= 76.9 for normal roads and 78.5 / 78.0 for motorways.

These values of $L_{eq,\ 16h}$ are for the UK "norm" of 0700 – 2300, but assuming that the 1 hour difference in start and finish times is not critical, it is assumed here that, for Road Traffic, $L_{day,\ 0600\text{-}2200}$ and $L_{eq,\ 12h}$ are numerically equal (i.e. the differences are well below 1dB, which is not considered significant, in the overall context of the calculations).

Thus, it was decided, in view of this equivalence, that in the case of Road Traffic Noise, it was a reasonable assumption to calculate numbers of people at risk using noise exposure data in terms of $L_{day,\ 12h,}$ but with Odds Ratios [Relative risk] derived from the Babisch data, which used $L_{day\ 0600\text{-}2200}$.

As Babisch himself noted, on page 52 of his Report:
"For quantitative risk calculations either the data referring to mean category values, or the fitted curve referring to the weighted data points, should be used."

As we have noted above, the numerical values of Relative Risk used by Babisch, in his Table 5, were those from the actual pooled data in his meta-analysis [Table 1 page 51], rather than the values generated by the polynomial equation of best-fit.

In other words;

Noise level dB	**Relative Risk or Odds Ratio**
< 60	1.0
61-65	1.05
66-70	1.09
71-75	1.19
76-80	1.47

Aircraft Noise
London Heathrow Airport.

For London Heathrow Airport, calculations were done assuming the available population exposure data in terms of $L_{day,\ 12h}$, together with values of the Odds Ratio derived from the Babisch report, assuming simple numerical equivalence with $L_{day,\ 16h}$.

London City Airport
For London City Airport, which is open from 6.30 am to 10 pm, and has no scheduled flights in the locally-defined 8 hour night period, it would also seem to be appropriate to use $L_{day,\ 16h}$ values in the estimation of the OR values. The available population exposure data in terms of $L_{day,\ 12h}$, was used, together with values of the Odds Ratio derived from the Babisch report, assuming simple numerical equivalence with $L_{day,\ 16h}$.

6.2 Overview of calculations

Using the formulae and MS Excel spreadsheet described in Section 2 of this Report, calculations were performed for the following situations and assumptions.

Noise Source	Descriptor used in Population exposure	Descriptor used in OR calculation	Health data	Results Table
Road Traffic Noise [2001] – all roads	$L_{day, 12h}$	$L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2001 AMI ICD10, I21-I22 Number of cases, Nc = 5991	Table 5 Section 6.3
Road Traffic Noise [2001] – Major roads	$L_{day, 12h}$	$L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2001 AMI ICD10, I21-I22 Number of cases, Nc = 5991	Table 6 Section 6.3
Road Traffic Noise [2001] – all roads	$L_{day, 12h}$	$L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2001 IHD Ischaemic Heart Disease (ICD I20 - I25) Number of cases, Nc = 27550	Table 7 Section 6.3
Road Traffic Noise [2001] – Major roads	$L_{day, 12h}$	$L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2001 IHD Ischaemic Heart Disease (ICD I20 - I25) Number of cases, Nc = 27550	Table 8 Section 6.3
London Heathrow [2006]	$L_{day, 12h}$	$L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2006 AMI ICD10, I21-I22 Number of cases, Nc = 6313 London-wide (see 6.4)	Table 9 Section 6.4
London City Airport [2006]	$L_{day, 12h}$	. $L_{day, 16h}$. [assumed = $L_{day, 12h}$]	2006 AMI ICD10, I21-I22 Number of cases, Nc = 6313 London-wide (see 6.5)	Table 10 Section 6.5

Each of these sets of results is tabulated in the following Sections 6.3, 6.4, and 6.5. The calculations used mean values of Relative Risk, derived from the Babisch report as outlined above. In addition, as an indication of the effect which the statistical uncertainty in the values of Relative Risk has upon the results of the calculations, results are given in Annex 2 of a “sensitivity analysis” using the upper bounds of the confidence intervals for Relative Risk, as given by Babisch in Reference 2.

6.3 Road Traffic Noise.

For a description of assumptions used, see Section 6.1 above.

Table 5. Risk of AMI due to Road Traffic Noise - ALL ROADS.

[Note Relative Risk (RR) and Odds Ratio (OR) assumed numerically equivalent throughout - see note under Figure 2]

NOISE SOURCE ROAD TRAFFIC NOISE ALL ROADS	**Relative Risk OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year Number of AMI cases Nc = 5991**
NOISE LEVEL $L_{day, 12h}$ dB	From $L_{day, 16h}$			
< 55	1	72.76	0.00	0
55-60	1	7.19	0.00	0
60-65	1.05	7.82	0.39	23
65-70	1.09	9.23	0.82	49
70-75	1.19	2.91	0.55	33
> 75 dB	1.47	0.1	0.05	3
SUM			1.81	108

Table 6. Risk of MI due to Road Traffic Noise - MAJOR ROADS

NOISE SOURCE ROAD TRAFFIC NOISE MAJOR ROADS	**Relative risk OR***	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year Number of AMI cases Nc = 5991**
NOISE LEVEL $L_{day, 12h}$ dB	From $L_{day, 16h}$			
< 55	1	94.23	0.00	0
55-60	1	1.99	0.00	0
60-65	1.05	1.13	0.06	4
65-70	1.09	1.43	0.13	8
70-75	1.19	1.15	0.22	13
> 75 dB	1.47	0.07	0.03	2
SUM			0.44	27

Note that for the All Roads situation, the largest number of potential cases of AMI [n=49] arises in the $L_{day, 12h}$ 65-70 dB band. This is due to the significant percentage exposed in that band [9.23%]. There are however significant contributions to the total of 108 cases from the bands from $L_{day, 12h}$ 60-65 and 70-75 dB.

In the Major Roads scenario a very high percentage of the population are exposed to levels below 55dB. Here nearly half of the AMI cases arise in the $L_{day, 12h}$ 70-75 dB band.

The previous calculations were then repeated for the broader category of Ischaemic Heart Disease IHD [ICD10:I20-I25]. The assumption is being made that one can use the same exposure-response curve as for AMI.

Table 7. Risk of IHD due to Road Traffic Noise - ALL ROADS.

NOISE SOURCE ROAD TRAFFIC NOISE ALL ROADS	**Relative risk OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year Number of IHD cases Nc = 27550**
NOISE LEVEL $L_{day,\ 12h}$ dB	From $L_{day,\ 16h}$			
< 55	1	72.76	0.00	0
55-60	1	7.19	0.00	0
60-65	1.05	7.82	0.39	107
65-70	1.09	9.23	0.82	226
70-75	1.19	2.91	0.55	152
> 75 dB	1.47	0.1	0.05	14
SUM			1.81	499

Table 8. Risk of IHD due to Road Traffic Noise - MAJOR ROADS.

NOISE SOURCE ROAD TRAFFIC NOISE MAJOR ROADS	**Relative risk OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected year Number of IHD ca Nc = 27550**
NOISE LEVEL $L_{day,\ 12h}$ dB	From $L_{day,\ 16h}$			
< 55	1	94.23	0.00	0
55-60	1	1.99	0.00	0
60-65	1.05	1.13	0.06	17
65-70	1.09	1.43	0.13	36
70-75	1.19	1.15	0.22	61
> 75 dB	1.47	0.07	0.03	8
SUM			0.44	122

As the inclusion of this broader category of IHD only involves an increase in the Number of cases, with other factors remaining the same as for AMI, the general observations made above still apply.

Thus for the All Roads situation, the largest number of potential cases of IHD [n= 226] arises in the $L_{day,\ 12h}$ 65-70 dB band. This is due to the significant percentage of the population exposed in that band [9.23%]. There are however significant contributions to the total of 499 cases from the bands from $L_{day,\ 12h}$ 60-65 and 70-75 dB.

In the Major Roads scenario a very high percentage of the population are exposed to levels below 55dB. Here half of the IHD cases arise in the $L_{day,\ 12h}$ 70-75 dB band.

6.4. Aircraft noise around London Heathrow Airport

For a description of assumptions used see Section 6.1.

In addition it was assumed that the total GLA population corresponding to the 2001 Census was 7,172,036 [see http://www.statistics.gov.uk/census2001/pop2001/london.asp]. The total number of AMI cases in the GLA area described in Section 4 was adjusted pro-rata according to the ratio between the population within the relevant 55 dB contour, and the total GLA population. This assumes that the populations around the airports are typical in their general cardiovascular risk factors to those of Londoners as a whole.

Table 9. Risk of AMI due to Aircraft Noise LHR - L_{day}

AIRCRAFT NOISE LHR **2006 Lday CONTOURS 2001 CENSUS**	**Relative risk** **OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year** Total Number of AMI cases, in GLA area = 6313. **Estimated pro-rata number within 55 dB contour = 320***
NOISE LEVEL dB	From $L_{day, 16h}$			
55-59	1	73.8	0.00	0
60-65	1.05	20.5	1.01	3.2
65-69	1.09	5.1	0.46	1.5
70-74	1.19	0.6	0.11	0.4
≥ 75 dB	1.47	0	0.00	0
SUM			1.58	5.1

NOTE: Percentage exposed based on $L_{day, 12h}$ contours.
* Total AMI cases in GLA area = 6313.
Estimated fraction of these within 55 dB L day contour = 363300 / 7172036 = 0.0507 – see table 4.
Estimated number within 55dB = 6313 X 0.0507 = 320

The majority of the estimated total of 5 cases arise in the $L_{day, 12h}$ band from 60-65 dB.

6.5 Aircraft noise around London City Airport

For a description of assumptions used see Section 6.1.
Again, the total number of AMI cases in the GLA area described in Section 4 was adjusted pro-rata according to the ratio between the population within the relevant 55 dB contour and the total GLA population.

Table 10. Risk of AMI due to Aircraft Noise LCY - L_{day}

AIRCRAFT NOISE LCY **2006 Lday CONTOURS 2001 CENSUS**	**Relative risk** **OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year** Total Number of AMI cases, in GLA area = 6313. **Estimated pro-rata number within 55 dB contour = 10***
NOISE LEVEL dB				
55-59	1	86.4	0.00	0
60-65	1.05	13.6	0.68	0.068
65-69	1.09	0	0.00	0
70-74	1.19	0	0.00	0
≥ 75 dB	1.47	0	0.00	0
SUM			0.68	0.068

NOTE: Percentage exposed based on $L_{day, 12h}$ contours.
* Total AMI cases in GLA area = 6313.
Estimated fraction of these within 55 dB L day contour = 11000 / 7172036 = 0.00153 – see table 4.
Estimated number within 55dB = 6313 X 0.00153 = 10

7. Discussion

One of the ways in which results of the kind reported here can be used is in assessing the implications of various “What if?” scenarios, which might, for example, be considered in the process of drawing up Noise Action Plans.

It was noted earlier that in the Road Traffic Noise - All Roads situation, the largest number of potential cases of Acute Myocardial Infarction AMI [n=49] arises in the $L_{day, 12h}$ 65-70 dB band, due to the significant percentage exposed in that band [9.23%]. But there are significant contributions to the total of 108 cases from the bands from $L_{day, 12h}$ 60-65 and 70-75 dB. See Table 5 above.

Another way of looking at this is that, if the number of people exposed to levels above $L_{day,12h}$ 70 dB were reduced to zero, the total number of potential cases of AMI would be reduced by 33%, from 108 to 72.
Similarly, for Major Roads, if the same strategy of reducing the number of people exposed to levels above $L_{day, 12h}$ 70 dB to zero were followed, the reduction in the number of cases would be 55%, from 27 down to 12. See Table 6.

As noted earlier, the inclusion of the broader category of Ischaemic Heart Disease IHD in the calculations involves an increase in the number of cases, with other factors remaining the same as for AMI. Thus, the general observations made above still apply.

Thus if the number of people exposed to levels above $L_{day, 12h}$ 70 dB were reduced to zero, the total number of potential cases of IHD would be reduced by 33%, from 499 to 333.
Similarly, for Major Roads, if the same strategy of reducing the number of people exposed to levels above $L_{day, 12h}$ 70 dB to zero were followed, the reduction in the number of cases would be 55%, from 122 down to 53. See Table 8.

The overall results, in terms of the estimated numbers of people in the GLA area potentially affected by Acute Myocardial Infarction AMI, and by Ischaemic Heart Disease IHD and the associated values of PAR% [Population Attributable risk %] can be summarised in Table 11 below, which compares the results for L_{day}:

Table 11 – Overall results – AMI and IHD ***.**

L_{day}	**Road Traffic Noise all roads**	**Road Traffic Noise. Major roads**	**London Heathrow Airport**	**London City Airport**
Number of People AMI	**108**	**27**	**5**	**0**
Number of People IHD	**499**	**122**	*** Not calculated**	*** Not calculated**
PAR%	**1.81**	**0.44**	**1.58**	**0.68**

* NOTE: As explained in Section 3, because of the assumptions which are made in extending the calculations to include this broader category of IHD, the calculations in this case were only made for Road Traffic Noise. Thus it was considered that the assumption that the same exposure-response curve could be used for AMI and for IHD could not reasonable be applied for estimating the number of cases of IHD due to aircraft noise.

It should be noted that the calculations treat Road Traffic Noise and Aircraft Noise separately. The possibility, for example, that some of the population exposed to high road traffic noise are also exposed to high aircraft (or other) noise, and therefore at potentially higher risk, is not covered in this study.

The values for PAR% derived in the present study are all significantly less than the 3.22% calculated by Babisch in Reference 2 for road traffic noise.

This is primarily due to the fact that, for the GLA area, as compared to the whole of Germany as included in the Babisch calculations, the percentage of people exposed to noise levels above an L_{day} of 60 dB has been estimated in Defra noise mapping as considerably less [20% compared to 31%]. See Table 12 below.

Table 12. Comparison of GLA area and Germany in terms of percentage of population exposed to various levels of Road Traffic Noise.

Noise level	**GLA all roads ($L_{day, 07.00-19.00}$)***	**Germany ($L_{day, 06.00-22.00h}$)***
< 50 dB	72.76 %	69.1
50 -55		
55 -60	7.19%	
60 -65	7.82 %	15.3
65 -70	9.23 %	9.0
70 -75	2.91 %	5.1
> 75 dB	0.10 %	1.5

*** Taken as numerically equal for UK data – see 6.1**

This figure of 3.22% also features in the 2005 WHO Report on "*Quantifying the burden of disease from environmental noise: Second technical meeting report"*
http://www.euro.who.int/Document/NOH/Noise_EDB_2nd_mtg.pdf

In that WHO Meeting Report it appears in the Conclusions, as being associated with *"the incidence of Ischaemic Heart Disease in Germany*". In fact the Meeting Report itself gives no details of the basis of this figure of 3.22% but it is known to be based on the same calculations which later appeared in the 2006 UBA Report by Babisch.

Mortality estimates

AMI

Babisch used a "percentage mortality" of 66% for Myocardial infarction in arriving at the following statement;

"In total, 3.2% of myocardial infarctions in Germany are due to the road traffic noise (if the noise hypothesis is true). This accounts for approx. 4,289 MI cases per year, of which approx. 66% are lethal.

As noted earlier in Section 4, if we take the most recent 2006 health statistics, for the GLA area, the total number of Acute Myocardial Infarction AMI deaths was 2926 out of a total number of cases of 6313, or 46% of the total number of cases. If we apply this figure to the estimated number of cases due to Road Traffic Noise [all roads] of 108, we arrive at a figure of approximately 50 potential deaths. That figure of 108 cases of AMI was derived using noise mapping data from 2001 as well as statistical health data on admissions with AMI from the same year. However the 2006 mortality estimate is used to approximate a "current view". If we use 2001 mortality data – see Section 4 – which provides a "retrospective" view, the relevant total number of deaths would be 5991 and the mortality rate would be 72.4%, implying 78 deaths.

IHD

Taking the most recent 2006 health statistics, for the GLA area, from the NCHOD website, the total number of IHD deaths was 7828 out of a total number of cases of

28791, or 27% of the total number of cases. If we apply this figure to the estimated number of cases due to Road Traffic Noise [all roads] of 497, we arrive at a figure of approximately 134 potential deaths.

The figures for the GLA area can also be considered in the light of a recent Report on "*Traffic noise reduction in Europe - Health effects, social costs and technical and policy options to reduce road and rail traffic noise",* commissioned by the T&E Foundation [Reference 7]. Here it was reported that the annual count of people suffering a fatal heart attack due to traffic noise is estimated for three countries only - see Table below. For two of these, Denmark and Germany, the annual count for ischemic heart diseases (IHD) is also known.

Number of people affected by heart diseases and the probability of heart diseases due to traffic noise in three European countries

Country	Annual count of people suffering a lethal heart attack	Annual count of people affected by IHD	Probability of a lethal heart attack for people exposed to > 60 dB	Probability of IHD for people exposed to > 60 dB
Denmark	200 - 500	800 - 2200	0.00026 - 0.00065	0.001 - 0.003
Germany	4,289	27,366	0.00017	0.001
Netherlands	300 - 1000	-	0.00016 - 0.00053	-

Sources: Babish, 2006; Danish, 2003; RIVM, 2005; probabilities calculated by CE Delft.

Based on these figures and the number of people exposed to noise levels above 60 dB(A) in the relevant countries, estimates were made of the probability of a fatal heart attack or ischemic heart disease and these probabilities were used to estimate the number of people likely to be affected by these diseases in the EU25 annually. To this end, for each country, the number of people exposed to noise levels over 60 dB(A) was multiplied by the respective probabilities of the heart diseases.
The aggregate results of this estimation procedure led the authors to conclude that *"over 245,000 people in the EU25 are affected by an ischemic heart disease due to [road and rail] traffic noise annually, of whom 94% (approx. 231,000)[are] due to road traffic noise. About 20% (almost 50,000) of these people suffer fatal heart attacks. Road and rail traffic noise are thus responsible for around 50,000 premature deaths per year in Europe."*

Comparison with Road Accidents and with the effects of Air Quality
The figure of approximately 50 potential deaths from AMI (and 134 from IHD, if the same exposure-response curve applies) associated with Road Traffic Noise should be seen in the context of other risks and causes of death. If, for example we consider Road Accidents the Transport for London website reports that 231 people, including pedestrians, were killed on roads in London in 2006.
See http://www.tfl.gov.uk/corporate/projectsandschemes/roadsandpublicspaces/2289.aspx .

In respect of the effects of Air Quality in London, the Mayor's Air Quality Strategy Progress Report to March 2006 (GLA - October 2006), indicates that 1031 premature deaths were predicted to occur due to PM_{10} (particles less than 10 micrometres in diameter) pollution in 2005. Another 1088 people were predicted to be admitted to hospital. Sources of these pollutants include not only road traffic and aircraft, but also (diesel) railways, industry and natural sources. Air quality in London is also affected by pollution from outside London and the UK.

8. Conclusions

In this present Report, the exposure-response relationship relating risk of Acute Myocardial Infarction to noise level, developed by Babisch, which was identified and reviewed in the initial review phase of the project, has been applied to the estimation of the number of cases of Acute Myocardial Infarction [ICD Code 10: I21-I22], in the GLA area, potentially arising from exposure to;

- Road Traffic Noise,
- Aircraft Noise.

In the case of Road Traffic Noise, additional calculations have been done to estimate the number of potential cases of Ischaemic Heart Disease IHD [ICD Code 10: I20-I25]. This was based on the assumption that the same exposure-response curve could be used for AMI and for IHD.

The study required the preparation of input data on:
- the occurrence of Cardiovascular diseases, and on
- the "Population Noise Exposure" within the GLA area, to Road Traffic Noise and Aircraft Noise.

The estimated number of people in the GLA area potentially affected by Acute Myocardial Infarction AMI as a result of exposure to **Road Traffic Noise is 108**, or about 1.8% of the total number of cases of AMI [5991 in London 2001].
For Ischaemic Heart Disease IHD, the estimated number of people in the GLA area potentially affected as a result of exposure to Road Traffic Noise would be 499.

Assuming that the same exposure-response relationship relating risk of Myocardial infarction to noise level, developed by Babisch and based on research data for Road Traffic Noise can be applied to Aircraft Noise, the estimated number of people in the GLA area potentially affected by Acute Myocardial Infarction AMI as a result of exposure to **Aircraft Noise around London Heathrow Airport, is 5.**

Because of the relatively low population exposure around London City Airport the calculations do not yield any cases of AMI as a result of exposure to **Aircraft Noise.**

The above results should be seen in the context of the various assumptions outlined in Annex 3.

The figure of approximately 50 potential deaths from AMI (and 134 from IHD, if the same exposure-response curve applies) associated with Road Traffic Noise should be seen in the context of other risks and causes of death, for example Road Accidents, where 231 people, including pedestrians, were killed on roads in London in 2006, and Air quality, where 1031 premature deaths were predicted to occur due to PM_{10} (particles less than 10 micrometres in diameter) pollution in 2005.

Research on the association between environmental noise and cardiovascular disease is an ongoing subject. New results are appearing all the time, and expert groups such as those set up by the World Health Organisation, and the UK Department of Health, keep such results under review.

The project documented in this current Report has provided a "mechanism" by which calculations of the kind reported here could be repeated when newer information, both on health effects and on population exposure become available.

9. References

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Nicole Porter, Independent Consultant, implemented the calculations in MS Excel.

Annex 1. The Brief [as at December 6 2007]

BRIEF – EFFECT OF NOISE ON PHYSICAL HEALTH RISK IN LONDON

1. Summary

To provide guidance on the robustness of published cardiovascular risk factors arising from ambient/environmental noise, using latest available World Health Organisation (WHO) and other reviews of evidence/criteria, and suggest best estimates of the factors from the range of published values. Use derived factors to generate estimates of the numbers of people at cardiovascular and related health risk from road and air traffic noise in London from available population exposure data (for example, from Defra London Road Traffic Noise Map) on a basis as near-compatible as possible with existing air quality-related estimates.

2. Background

Ambient, or environmental, noise is popularly perceived as primarily a qualitative issue for health – in other words, one affecting health in its broadest definition (e.g. the WHO definition as not just lack of harm, but a positive sense of well-being) and hence in terms of disturbance, annoyance, quality of life etc. While these are important issues, there are indications that ambient noise may also have health impacts in the narrower, physiological sense. One of the main areas of study into potential health impacts has related to increased risk of heart disease (ischaemic heart disease and myocardial infarction) as distinct from the universally accepted impacts of higher levels of noise, such as that within some industrial premises, where the main effect is seen as damage to hearing. Public bodies in some countries in Europe (e.g. the Netherlands) appear to have accepted non-auditory physiological health impacts as of sufficient risk to have guidance to address them. Recently, significant publicity has been given to preliminary findings by a WHO group of experts looking into the burden of disease from environmental noise[4].

In the UK, this issue does not appear to have been given the same degree of attention and credence. While recognising the possibility of physiological impacts, a more cautious 'lack of absolute proof' viewpoint has tended to prevail. Reasons for differences in official recognition in different countries are not entirely clear.

In 1998 a UK government-sponsored project reviewed the evidence for physiological and other impacts from noise and concluded (on physiological impacts) that while there probably were such impacts, further research was needed to confirm these and their scale. Defra and the Department of Health (DH) then jointly commissioned some new scientific studies, though these mainly focussed on non-physiological effects. These were completed between 2000 and 2002 and are published on the DH website.

Following the foundation of the GLA, a 'Rapid Review on Noise and Health for London' was commissioned by the GLA in 2001, although this mainly reviewed similar evidence. Again, this review concluded that noise could have cardiovascular health effects, but did not quantify them, suggesting that the effect was small and that noise was not considered likely to be a major risk factor for heart disease. On this latter point, however, it should be noted that, given the large numbers dying each year from heart disease (in excess of 10,000 in London in 2001, according to the

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[4] **Quantifying burden of disease from environmental noise: Second technical meeting report - Bern, Switzerland, 15 – 16 December 2005.**
Hhttp://www.euro.who.int/Document/NOH/Noise_EDB_2nd_mtg.pdf

London Health Observatory[5]), even a small additional risk from noise could equate to significant numbers of premature deaths.

Since the GLA review, a number of further studies have been published, in particular by WHO, and these seem to increase support for the existence of tangible physiological health impacts. A short study to update understanding of the strength of the latest evidence and to apply best available estimates of risk to population exposures to ambient noise in London is therefore appropriate.

3. Objective
This is intended to be a brief desktop study to enable the GLA to update its understanding of the issues and to make preliminary, although as robust as practicable, estimates of the impact of noise on the cardiovascular and related health risk of Londoners, based on available published risk factor estimates and population exposures to noise.

4. Aims
In summary, the aims of the project are to:

1. Briefly review and list the latest evidence and published policies and/or guidance (adopted or proposed) of WHO and public bodies or authorities in other countries on the link between noise and physiological health impacts, providing a view on the robustness of the risk factors they use or currently propose and suggest best estimates of the risk factors and probable margins of error, and summarising plausible causal pathways to assist in popular interpretation of estimates. As far as possible, this should apply a standard of evidence similar to that applied to equivalent risk factors for air quality impacts.
2. Apply the suggested risk factors to available London population noise exposure data derived from maps for road traffic noise, Heathrow and London City Airports to determine overall impacts.
3. Make summary comparisons between the best estimate risk factors and outcomes for two other health impacts from road traffic in London (e.g. air pollution impacts and road traffic accidents), to place the noise outcomes in context.
4. Clearly explain the methodology used to derive the risk factors and to apply these to the population exposure data to derive overall numbers of premature deaths, QALY/DALYS and any other outcomes analysed, so that the client can derive and apply revised factors in future as scientific understanding advances and/or new population exposure data become available.

5. Brief
The proposal is for a brief desktop study, with two reporting elements, to update the GLA's understanding of the evidence for the cardiovascular and related impacts of ambient noise and to quantify, as far as possible, implications for Londoners' health on the basis of the best available evidence.

Element one will review the latest evidence and the policies and/or guidance adopted or currently under consideration (e.g. in draft papers) by the WHO, and also the evidence utilised by public bodies or authorities in other countries that already accept a link between noise and physiological health, listing the bodies that accept a link and their reasons as far as practicable, including a summary of the hypothesised causal mechanisms. The assessment should apply, as far as practicable, a standard similar to that applied to the assessment of the strength of evidence for air quality health impacts. It will report the strength of evidence, including issues related to night time noise exposure and determine the best estimate for the factors and the range of the

[5] Hhttp://www.lho.org.uk/HIL/Disease_Groups/Cardiovascular.aspx

most likely values (including applying the risk factors used by public bodies or authorities in other countries) of standard metrics, such as the contribution to overall myocardial infarction mortality rate, number of premature deaths per year and QALYS/DALYS. Summary comparisons will also be made between these results and appropriate equivalent outcomes for up to two other health impacts from road traffic (e.g. impacts of air pollution from road traffic, deaths due to road traffic accidents), chosen in consultation with the client.

Element two will then apply these factors to London noise exposure data (e.g. Defra London Road Traffic Noise Map (LRTNM) and its population exposure data (to be supplied by the client) and, separately, to the published noise contours and population exposures for Heathrow and London City Airports, adapting the factors and/or the exposure data[6] as necessary, to determine the health impacts on those affected (including indication of the ranges of likely values). It should explain clearly how these values have been derived and the methodology used so that they can be applied by the client to future updated maps and to maps for other noise sources (such as railways) individually, and, if feasible, consolidated (multi-source) noise maps, as they become available. Uncertainties in the data and their sources should be clearly stated.

For aircraft noise impacts, in particular, the most exposed populations around Heathrow and London City airports may not be demographically similar to the London average (in terms of age, other health factors affecting cardiovascular disease risk, ethnicity etc.). Quantification of such equalities issues is not expected to be feasible within the resources available for this study. The report should discuss the principles, as far as is possible in the light of current knowledge, governing how demographic differences and associated differences in health profiles could affect risk associated with noise exposure, and indicate where or how far future equalities analysis might be feasible. Health profiles can be found on the London Health Observatory website at http://www.communityhealthprofiles.info/

6. Deliverables

1. A draft report on element one for discussion and agreement with the client, in electronic form.
2. A draft final report for discussion and agreement with the client, in electronic form.
3. A final report - both a printed version and electronic versions in both Word and PDF formats.
4. Provision should be made for a progress meeting following the draft report on element one and a meeting to discuss the draft final report, with the client at City Hall.

7. Timescale

The progress meeting will be held as soon as practicable after provision of the draft report on element one in late December 2007. The draft final report should be provided by 15 February 2008 at the latest, with a discussion meeting as soon as practicable afterwards. The final report should be provided by 14 March 2008 at the latest.

[6] For example, the preliminary WHO risk factors relate to $L_{Aeq,\ 16h}$ noise levels for the period 06.00 to 22.00 (see Footnote 1, especially: Annex 2, Table 2). The LRTNM population exposure data are available for L_{den}, $L_{Aeq,\ 12h}$, $L_{Aeq,\ 4h}$, and $L_{Aeq,\ 8h}$ only and the periods are divided at 07.00, 19.00 and 23.00. Although the WHO report suggests that L_{den} may be used as a proxy for $L_{Aeq,\ 16h}$, this is on the assumption that nighttime noise levels will be approximately 10 dBA lower than daytime ones, which is not generally true for London where noise levels typically fall by much less at night. It will be necessary therefore to use best estimates based on the exposures to the available indices, since fundamental recalculation of the map would be necessary to derive the 06.00 – 22.00 data and is beyond the scope of this study.

Annex 2. Effect of uncertainty in the Exposure-response relationship – Sensitivity analysis.
In his 2006 Report [Reference 1] Babisch gives the results of his meta-analysis as follows. See Table 1 page 51.

	Relative risk **OR**	**95% Confidence intervals**
NOISE LEVEL L_{day}		
< 55	1	
55-60	1	
60-65	1.05	0.86-1.29
65-70	1.09	0.90-1.34
70-75	1.19	0.90-1.57
> 75 dB	1.47	0.79-2.76

As an indication of the effect which the statistical uncertainty in the values of Relative Risk has upon the results of the calculations, one of the sets of results in the main part of the report has been re-calculated using the upper bounds of the confidence intervals for Relative Risk, rather than the mean value.

The original MI results – for Road Traffic Noise, all Roads, were as follows;

NOISE SOURCE ROAD TRAFFIC NOISE ALL ROADS	**Relative risk** **OR**	**Percentage Exposed %**	**PAR%**	**PAR = number affected per year** **Number of cases Nc = 5991**
NOISE LEVEL $L_{day,\ 12h}$ dB	From $L_{day,\ 16h}$			
< 55	1	72.76	0.00	0
55-60	1	7.19	0.00	0
60-65	1.05	7.82	0.39	23
65-70	1.09	9.23	0.82	49
70-75	1.19	2.91	0.55	33
> 75 dB	1.47	0.1	0.05	3
SUM			1.81	108

The re-calculated results are;

NOISE SOURCE ROAD TRAFFIC NOISE ALL ROADS	**Relative risk** **OR - UPPER BOUND VALUES**	**Percentag Exposed %**	**PAR%**	**PAR = number affected per year** **Number of cases Nc = 5991**
NOISE LEVEL $L_{day,\ 12h}$ dB	From $L_{day,\ 16h}$			
< 55	**1**	72.76	0.00	0
55-60	**1**	7.19	0.00	0
60-65	**1.29**	7.82	2.22	133
65-70	**1.34**	9.23	3.04	182
70-75	**1.57**	2.91	1.63	98
> 75 dB	**2.76**	0.1	0.18	11
SUM			7.07	424

This has the overall effect of increasing the number of people affected by a factor of about 4, but most of the effect arises in the noise level bands of 60-65 and 65-70, rather than in the highest noise band. **This represents an extreme case. If, in contrast, the lower bound values for OR had been used, which are all less than 1.0, the predicted number affected would be zero.**

Annex 3. Assumptions used in the report

During the course of the Report, various assumptions have been made, and explained. This Annex brings these together in one place in the order in which they first occur in the main part of the report.

1. We have assumed that the Exposure-response relationship developed and used for Road Traffic Noise can be used for the calculations of Aircraft Noise. This is based on the comment by Babisch in his 2006 Review [Reference 2]:

"Regarding aircraft noise - and particularly the ongoing debate on night-flight restrictions in the vicinity of busy airports - ***no other alternative exists at present than to take the MI risk curves derived from road traffic noise studies as an approximation for aircraft noise.*** *Since aircraft noise acts on all sides of a building, i.e. different to road traffic noise, the suspicion exists that the effects induced by aircraft noise could be greater than those induced by road traffic (Babisch 2004a; Ortscheid and Wende 2000). This may be due to the lack of evasive possibilities within the home, and the greater annoyance reactions to aircraft noise, which are usually expressed in social surveys (Miedema and Vos 1998)."*

2. In extending the calculations to include the broader category of IHD, the assumption is made that one can use the same exposure-response curve as for AMI. In his 2006 review report Babisch suggested that similar calculations could be made with respect to all ischaemic heart diseases (IHD) - using the same curve for the relative risk. He noted [page 65 of Reference 2] that:

"These health endpoints are similarly considered in the noise hypothesis (see reaction schema in Figure 1) (Babisch 2002; Passchier-Vermeer and Passchier 2000). It may be a reasonable assumption that the relative risks for these endpoints show a similar relationship across noise categories. In cross-sectional and prospective cohort studies, the relative risks found for these health endpoints did look similar, within the statistical boundaries of uncertainty (confidence intervals) (Babisch et al. 1993a) (Babisch et al. 1999). However, the severe and manifest event of a myocardial infarction can be most reliably assessed in studies (Bormann et al. 1990)."

3. Because of the assumptions which are made in extending the calculations to include this broader category of IHD, the calculations in this case were only made for Road Traffic Noise. Thus it was considered that the assumption that the same exposure-response curve could be used for AMI and for IHD could not reasonable be applied for estimating the number of cases of IHD due to aircraft noise.

4. The calculations of estimated numbers of cases of AMI are based on the total number of cases of AMI within the International Classification of Diseases ICD code 10:I21-I22 which includes "recurrent AMI". This provides a "worst-case" estimate of the potential number of cases in this study. Another reason for using this data is that mortality rates are not readily available for ICD Code 10: I21 alone.

5. A number of necessary assumptions are made about the relationship between various descriptors of noise exposure. These are described in considerable detail in Section 6 and this detail is not repeated here.

6. In the calculations for Aircraft Noise it was assumed that the total GLA population corresponding to the 2001 Census was 7172036. Thus the total number of AMI cases in the GLA area described in Section 4 was adjusted pro-rata according to the ratio between the population within the relevant 55 dB aircraft noise contour, and the total GLA population. Thus it was assumed that the distribution of MI cases across the GLA area was uniform.

An alternative approach would have been to examine health data at a smaller element of geographical resolution such as Borough, or Ward-level. This approach presents its own statistical issues, and resources were not available in this small initial study to relate such data to airport noise contours on a GIS basis. Future studies might explore such an approach.

7. It should be noted that the calculations treat Road Traffic Noise and Aircraft Noise separately. The possibility, for example, that some of the population exposed to high road traffic noise are also exposed to high aircraft (or other) noise, and therefore at potentially higher risk, is not covered in this study