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CAN WE BASE ENVIRONMENTAL NOISE STANDARDS ON HEALTH EFFECTS ?

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1. INTRODUCTION

Because there are often severe technical, economic and social constraints on what can be achieved in practice, noise control is not simply a matter of setting targets and then taking action as required. The assumed benefits of noise control action must be carefully weighed against these costs, and this is hard to do when the most widely used indicator of noise effects is simply "annoyance". It is clear that a general change-over to some more tangible indicator of effects such as effects on health, might enable the setting of future noise targets with greater transparency. The European Commission has moved in this direction as suggested in the 1996 EC Green Paper "Future Noise Policy" (1), and is developing a new Directive on the Assessment and Reduction of Environmental Noise, establishing target values, and an obligation to take action to reach such targets.

It is against this background that the National Physical Laboratory (NPL), together with the Institute of Sound and Vibration Research (ISVR) began a project in January 1998 for the UK Department of the Environment, Transport and the Regions (DETR) to review noise standards used for assessing the health impact of environmental noise. The objectives of the project were, to consider existing information to establish noise levels at which there may be particular effects on the population, and from this, to advise on the feasibility of establishing effects-based standards which could be used to inform the setting of objectives and targets.

In short, DETR wanted to know how, or even whether it is possible, to derive robust health effect-based noise standards. They needed to know whether health effects actually exist at typical levels of environmental noise and if they can be reliably quantified. Additionally they needed to know what other factors should be considered in establishing practical effect-based assessment methods. This paper explains how the work was carried out, summarises the conclusions, and puts forward an approach to using the information acquired in the study. It also includes a summary of the activities of the new European Commission Working Group on Noise Dose/Effects and describes related work also funded by DETR on an Inventory of UK research on Noise and Health.

2. WORK STRATEGY

The initial work was divided into two phases, review and feasibility study.

Phase 1- Review The review phase was split into three stages;

1. A review of literature on the effects of environmental noise, An analysis was made of existing review literature on the effects of environmental noise. Much of the work had already been done in the extremely comprehensive study undertaken by a committee of experts on

behalf of the Health Council of the Netherlands, and published in 1994 under the title Noise and Health (2). In the interests of efficiency of effort and in view of the short time available, our review took the 1994 report as its starting point. A number of key review papers since 1994 were then identified and have been used to varying degrees in the course of this work.

2. A review of current standards and noise criteria/limits in operation in the UK and other EU countries. The aim of the review of noise criteria was to summarise the standards and limits used to control environmental noise, and where possible to find out the origin and justification for the numerical noise limits. The starting point for this review was two key publications. In 1994 Dieter Gottlob of the German Federal Ministry of the Environment presented the results of an extensive review of community noise regulations (3). In 1995 work was completed at NPL on a review of national practices on the assessment of industrial noise (4). For this project, requests for updated and additional information were sent to representatives in EU countries. In the requests, the aims of the project were described and information was sought in three main areas related to the measurement and assessment of environmental noise: the legislative or regulatory framework, the noise limits where specified (and units), and a brief history of research findings or any other basis against which the standards and/or noise limits were developed.

3. A review/critique or "guide to interpretation" of the 1995 WHO Community Noise Guidelines document. This was used to highlight the difficulties of setting over-precautionary noise limits based on scientific evidence alone.

Phase 2 - Feasibility study

This phase considered whether effects-based standards can realistically be set in the UK context. The findings are based on;

- The extent to which there is general agreement on the existence of an effect due to noise.
- The extent to which there is general agreement on the noise-exposure relationships and how reliably these can be used to set threshold indicators for effects.
- The uncertainties associated with combining separate effects to determine an overall impact on health
- The role of other factors apart from noise exposure level in setting practical, useful and attainable noise criteria.

3. OUTCOME OF THE STUDY

The detailed results of this review study are provided in a report, copies of which are available from NPL (5). The results are reported in three main sections, summarised as follows;

An examination of the scientific evidence for health effects due to noise,

There are a number of definitions and defined requirements for (good) health but it is concluded that a descriptor that can be used to assess the impact on health, and can provide a framework on which to base a method to balance costs and benefits, is the most useful to the decision maker.

The literature confirms that there are a number of potential effects of noise on health, although the evidence in support of actual health effects other than those based on reported bother or annoyance and on some indicators of sleep disturbance is quite weak. The available literature tends to be contradictory. In general, it is often the research studies with the least control over bias and confounding factors which show the strongest effects. There are serious methodological difficulties involved in being able to carry out definitive research.

This also means that significant effects amongst the most susceptible minority of the population remain scientifically plausible, even if unproven.

On examining existing information on exposure-response relationships based on scientific evidence, we can draw some conclusions from the primary research. Since the evidence in support of potential health effects other than annoyance is either contradictory or controversial , we cannot at present define any precise exposure-response relationships for any effects other than annoyance, and there is some uncertainty even for that effect. There are many non-acoustic factors involved in both annoyance and other effects, each of which undoubtedly adds to the general variability in the data. The scientific evidence suggests thresholds below which it is possible to infer that there are no significant health impacts. Equivalent thresholds at the upper end of the scale above which definite health impacts are likely are much more difficult to determine.

The possible links between observable and mostly short-term effects and longer-term impacts on health are even more problematical. How might one effect modify another? What precise role is played by effects-modifiers and confounding variables such as diet and lifestyle. What makes one individual more susceptible than another? Are there any hidden costs of adaptation remaining so far undiscovered because they have not been previously looked for?

An investigation of the practical noise criteria used to assess environmental noise,
Practical noise targets are a compromise between the desirable and affordable. The desirable relates to the thresholds suggested by the scientific evidence below which no effect is expected. The affordable involves weighing the costs and benefits in monetary and social costs. Practical noise limits are usually set above these lower desirable thresholds.

On reviewing environmental noise regulations and standards in the UK and in other EU countries, we find that existing standards and regulations usually take the results of primary research into account to some extent, but social, political and historic factors are at least as important. It is very important to be clear about the role played by these factors in the development of current standards and regulations and their likely role in future developments.

A guide to the interpretation of the WHO guidelines,
In view of the uncertainties involved in setting standards, there are moves within Europe to adopt a precautionary approach when setting future noise standards and regulations to protect against possible health effects. An example of this is the way in which the recent 1995 WHO guidelines(6) have been interpreted in some quarters. It is necessary to consider the wider consequences of any over-precautionary approach in the context of potentially unacceptable impacts in other areas, such as costs or limits on the freedom to travel. Many individuals might consider a certain amount of noise to be a fair price to pay in exchange for the personal freedom granted by the motor car, yet the quickest way to cut environmental noise levels at a stroke would be to ban cars.

4. FURTHER INTERPRETATION

In this section we suggest an approach to the interpretation of the information arising from the review which might be used to indicate the relative importance of various effects and

which could be useful in the process of setting standards. Figures 1 and 2 illustrate the general position in the UK in relation to the percentages of the population of England and Wales exposed to different noise levels measured outside their homes (7) and the likely percentages of those populations affected by noise in different ways. Each effects curve is forced to a generic s-shape with the centre, slope and maximum effect varied in accordance with professional judgement. The precise positions of the various effects curves cannot be considered to be definitive at this time for two reasons. First, there is uncertainty in the literature regarding the shape of the various exposure-effect curves. Second, there is some uncertainty regarding the units in which each effect is measured. For example, the generic daytime annoyance curves as shown could be considered as representing the percentages describing themselves as either moderately or extremely annoyed. This ought to make a great difference to the political interpretation of any results, yet different researchers continue to measure such effects in different ways. As another example, should the hearing loss and sleep disturbance curves represent either the slightest detectable effect or effects of such magnitude that they have a particularly significant effect on an individual's quality of life? The issue of clinical significance is relevant here (8). If the problems of confounding factors could be overcome, then epidemiological research may reveal weak but statistically significant associations between exposure and effect, for example elevated blood pressure and noise exposure outdoors. But this does not of itself mean that these small changes necessarily have any clinical significance. Finally, it is important to note that the available information on some these effects relates to noise exposure at the receiver and not to the magnitude of the effect when residents are indoors and possibly protected by noise insulating facades at the higher outdoor noise levels.

Figures 1 and 2 clearly show that the relative significance of the different noise effects varies considerably in terms of the percentages of the overall population potentially affected. For example, the generic annoyance curve on Figure 1 shows around 20% affected by some degree of annoyance at 60 daytime L_{Aeq} measured outdoors but it is important to remember that this is 20% of the 26% exposed at that noise level (i.e. around 5%) and not 20% of the whole. Moving up the scale, we have possibly less than 5% of exposed persons subject to weak cardiovascular effects at 70 daytime L_{Aeq} measured outdoors, which is less than 1/10 of a percent of the population as a whole. While noise induced hearing loss can constitute a major disability, there would seem to be virtually nobody at risk of even the slightest degree of deafness caused by environmental noise.

Figure 2 shows a similar pattern with respect to night-time noise. According to the notional curves shown, only a very small percentage of the overall population would appear to be in locations where night-time outdoor noise levels are high enough to cause major disturbance.

It is also clear from the figures how existing guidelines such as the often quoted 55 L_{Aeq} recommendation from the 1980 WHO criteria document (9) fit into the overall scheme of things. Clearly, only a small percentage of the population exposed at 55 daytime L_{Aeq} measured outdoors are affected by annoyance, and virtually none of them are affected in other ways. On the other hand, something over 65% of the population are exposed at this level. This illustrates both the conservative nature of the 55 L_{Aeq} guideline value in terms of effects and also the likely difficulty in being able to do anything about it anyway.

Subject to the general uncertainty regarding the precise shape of the various exposure-effects curves, this analysis leads to the general conclusion that health effects other than reported annoyance, and some relatively moderate degree of sleep disturbance, might only be a problem for a small proportion of the overall population. This conclusion does not diminish the importance of those effects for individuals, but it might influence government when establishing priorities for future noise control effort. Of course, the only way to overcome this existing uncertainty is to carry out carefully targeted research. However it is difficult to avoid the conclusion that any such research is unlikely to come up with any more definitive results than in the past unless some considerable ingenuity in terms of both methodology and theory is brought to bear. The case for first attempting to find some way of selecting the most susceptible individuals from the general population before proceeding to any more general research is made all the more clear by this analysis.

5. EC WORKING GROUP 2

Since the Copenhagen Conference in September 1998 (10), the various European Commission Working Groups working towards the new Directive can be considered as well established. The Terms of Reference of EC WG2 and its planned timescales are given below.

Terms of Reference of European Commission WG2 Dose/effect

Scope

The WG shall elaborate a set of relationships between noise exposure (dose, in terms of an agreed indicator) and the effects of the noise.

Objectives and work programme

The WG shall:

- provide dose/effect relationships for annoyance, sleep disturbance, speech interference and other effects as appropriate; this shall be done for separate types of noise. The issue of combined effects of noise pollution and dose-effect relationships for vulnerable groups should also be addressed.
- provide proposals for indices covering cases not comprised by the proposals of WG I
- define the needs on dose/effect research and play an active role in the initiation and co-ordination of that research (in close co-operation, with WG Research)
- make proposals for the dissemination of gathered information to the public, and to national, local and regional authorities
- make a proposal for the setting of targets by national, regional and local authorities making use of harmonised dose/effect relationships
- co-operate closely with WGI, WG Research, ISO/TC43/SC I (i.e. WG40, WG45 and WG49) and ICBEN.

Time-scales

Start of work:	September 1998.
Inventory of existing material and research needs:	March 1999.
Initiation of research:	1998 -2000.
Yearly progress reports:	1999,2000,2001.
Text for position paper with recommendations for remaining indicators, dose/effect relations,	
Dissemination and target setting:	June 2002.
Publication of the position paper:	August 2002.

Working Group 2 has held 4 intensive meetings since its inception. Clearly, in fulfilling its Terms of Reference and meeting its various objectives, it was important for this Group to take full account of the considerable amount of research already reported on health effects and relevant research currently in progress in various Member States. The UK input to this process is outlined in the next section.

6. AN INVENTORY OF UK RESEARCH ON NOISE AND HEALTH

In order to assist the Chairman of EC WG2, at the end of 1998, he requested all Member States represented to undertake research in order to provide the following information only in respect of their own countries;

1. An inventory of noise and health research projects currently in progress, and an inventory of work completed in the years 1994-98. This was to exclude direct effects on hearing.

2. An evaluation of this research in order to identify an inventory of research requirements.

The initial report on item 1 was made at a meeting of WG2 in Paris on January 6 1999, although it was accepted that this left insufficient time for a proper assessment of research completed and in progress. Further discussion of the inventory took place at the WG2 meeting in Leiden in February 1999, and a number of specific research proposals were prepared.

Under a contract with DETR, NPL prepared the inventory of research in the UK and this has been published in a recent NPL report (11). The material included in the UK inventory is also available in electronic format, and is intended to be accessible from either the NPL or DETR Web sites at the following addresses:-

http://www.npl.co.uk/npl/acoustics/detrinventory/index.html
http://www.environment.detr.gov.uk/airq/nnp/index.htm

The report also outlines research requirements arising from the inventory, as well as research requirements identified at the 1997 Institute of Environment and Health Seminar on Non-auditory health effects of noise (12), and requirements listed recently by a Task Group of the World Health Organisation (13).

The results of this activity by WG members are intended to feed directly into the specification of research to be done during 1999 to 2002 and into the Position Paper which the Chairman and Co-Chair are required to produce for the Commission by August 2002.

7. CONCLUSIONS

To address the question posed in the title of this paper, we feel that, given the present state of knowledge, apart from annoyance, sleep disturbance and speech interference effects, it would be unwise to base future environmental noise standards and regulations on what are at present hypothesised non-auditory health effects until future research can make the present confused situation clearer. There could be greater transparency in the way which future standards and regulations are developed so that the public can become more aware of both the strengths and limitations of these standards. An increased emphasis on non-

auditory health effects, as opposed to annoyance, as the outcome variable may lead to this greater transparency, although there is considerable doubt at the time of writing as to the magnitude of these effects due to environmental noise. To ensure that non-auditory health effects are included in the development of future standards, research is required. This must be carefully designed, not only in terms of its planning and execution, but also in terms of setting precisely defined and achievable objectives. The activity of EC Working Group 2 in systematically assessing past and current research across Europe and elsewhere, and developing recommendations, is a key part of the process of improving further research in this area.

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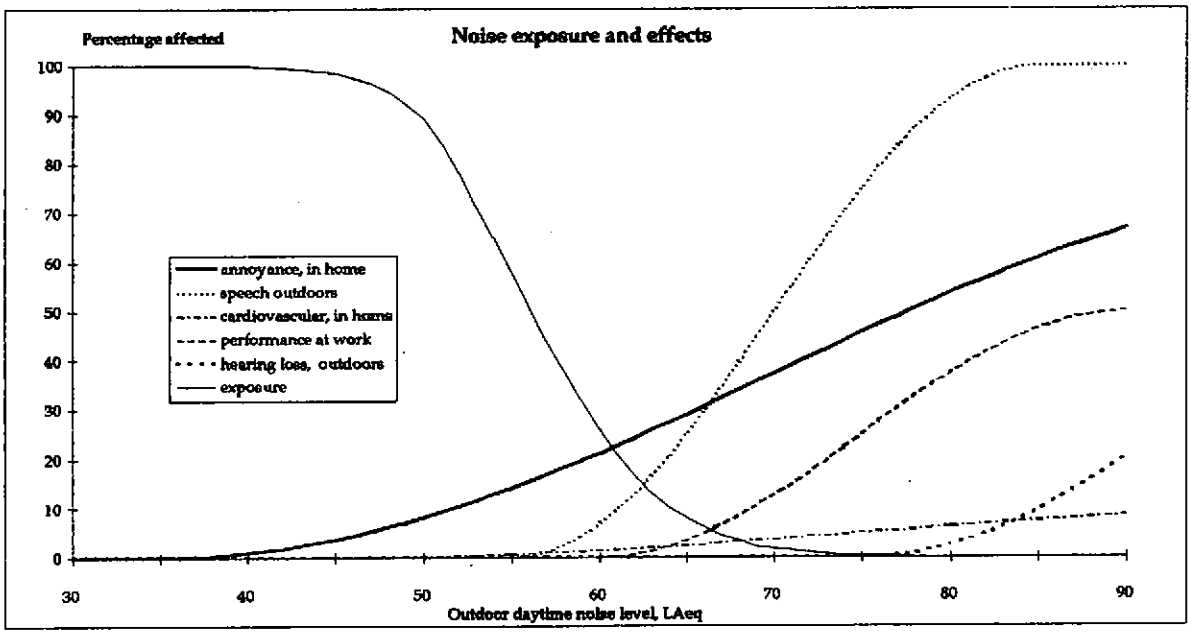

Figure 1. Day-time noise exposure and effects

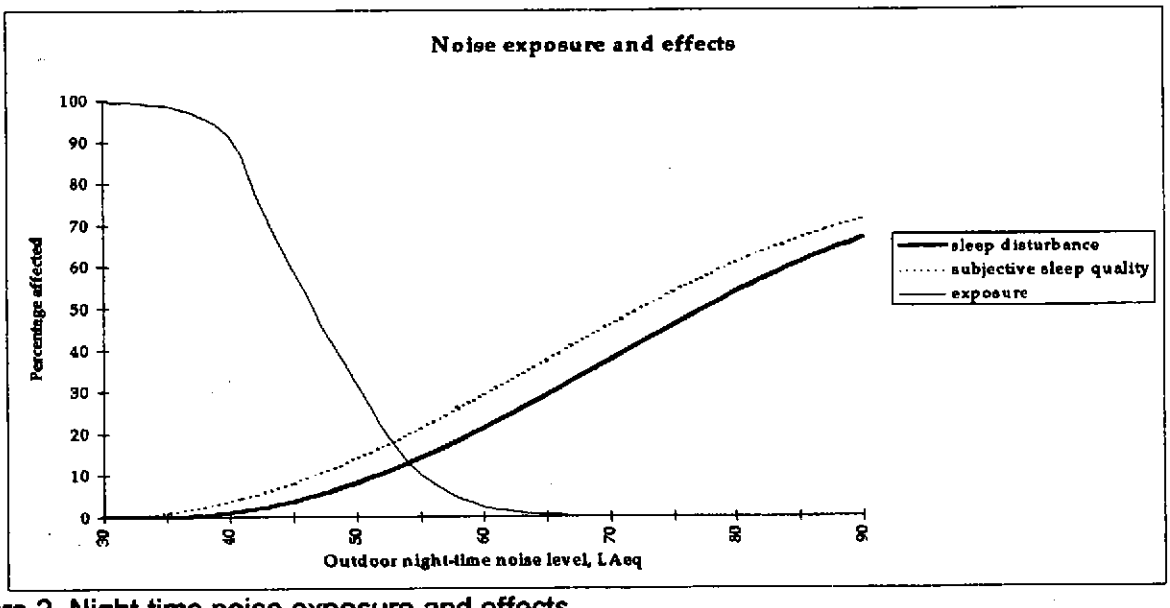

Figure 2. Night-time noise exposure and effects

NOTE. Whilst the shape of the above curves is based on the literature, they are only intended as notional examples, and should not be taken as definitive.