Strategic level assessment of the health effects of transport noise

A. L. Brown

Urban Research Program/Griffith School of Environment, Griffith University, Brisbane, Australia

ABSTRACT

Noise generated by surface and air transport is routinely considered in project-based environmental assessments. Sophisticated tools are utilised in prediction, noise mitigation, and assessment of noise impacts. These estimate human annoyance – even though there is a well-documented range of health effects of transport noise beyond annoyance. Focus on "annoyance" alone has had two important consequences. Firstly, it tends to have little traction with decision-makers. Secondly, despite the availability of assessment tools at the project level, there has been little consideration of transport noise at strategic levels. The extent of annoyance is a useful criterion in choosing between alternative highway routes at the project level, but not to assess impact of, say, area-wide transport options. This has now changed. Accumulated evidence regarding health effects of environmental noise has been published by the WHO Regional Office for Europe as initial guidance for quantitative risk assessment of environmental noise—based on Environmental Burden of Disease (EBD) methodology and the metric Disability-Adjusted Life Years (DALY). Synthesized reviews of health effects of environmental noise (cardiovascular disease, cognitive impairment, sleep disturbance, annoyance, hearing impairment and tinnitus), and exemplary estimates of the burden of its health outcomes now allow for inclusion of transportation noise in quantitative Heath Impact Assessments at aggregated strategic levels—in regional or national transport planning, and in assessment of policy options such as road pricing, land use planning, energy costs, modal shifts etc. that can influence the exposure of populations to transport noise at strategic levels.

NOISE AND PROJECT-BASED ENVIRONMENTAL ASSESSMENT

Noise is a major environmental issue, particularly in urban areas, affecting large numbers of people. The Guidelines for Community Noise (WHO, 1999) define environmental noise (also known as community, residential or domestic noise) as noise emitted from all sources except noise at the industrial workplace. The EU Directive on the management of environmental noise (2002/49/EC) defines it as unwanted or harmful outdoor sounds created by human activities, including noise from road, rail, airports and from industrial sites.

Noise is an environmental issue frequently included within project-based Environmental Assessments (EA) of developments (Burgess and Finegold, 2008), including noise from transport sources for all road, rail and air projects. In general, there is wide experience in such assessments. There is recognition of where and how noise should be included within the scope of an assessment, either because the development is a potential generator of noise, or because the development may contain noise-sensitive uses that will become exposed to existing noise sources from outside the development site (say a major land development proposed in the vicinity of airport flight paths). There has also been widespread development and application of prediction methodologies for estimating levels of noise from all source types, both the emission levels of the sources themselves, and the levels at receptors after they have been attenuated along propagation paths from the noise sources. Regulations, guidelines and criterion levels (local, or international as in WHO (1999)) are available to evaluate the significance of future exposure levels predicted in this way. Mitigation strategies to reduce predicted high levels of exposure are also widely known and generally practised where possible. Mitigation strategies include source emission controls, modification of the transmission path between source and receivers such as in the use of barriers for surface transport modes, or shielding receptors as through increasing in the attenuation of the building envelopes of residential buildings or schools. Mitigation strategies for noise in the assessment of proposed developments also often includes planning dimensions, such as increasing, where possible, the separation distance between source and receivers. Description of the inclusion of noise considerations in project-based EA is extensive (eg Canter, 1996; Morris & Therivel, 2009).

EFFECTS OF NOISE CONSIDERED WITHIN PROJECT-BASED ENVIRONMENTAL ASSESSMENT

Though particular projects have included the effect of noise on wildlife, most EAs are limited to the impact of noise on people (Morris & Therivel, 2009). A great deal is known about the effects of noise on humans with measurable effects including: impacts on auditory health, interference with speech communication, sleep disturbance and effects on other human activities, performance effects, cognitive effects in children in learning situations, annoyance, and many physiological impacts on humans including cardiovascular effects (WHO, 1999). Despite this, most assessment of the effects on humans are based on the magnitude and extent of human annoyance with noise, and occasionally on the extent of the disturbance to particular activities such as sleep and communication. Most criterion levels used in EA, say for limits on aircraft or surface transport noise, and to determine when mitigation strategies are required, have been determined through exposure-response studies in which the response is human annoyance. One of the reasons for this is that knowledge of some of the effects of noise is to acute expo-

sures (such as in laboratory experiments)—it being much more difficult to examine effects such as sleep disturbance to chronic noise exposure. While there is extensive knowledge of the extent of exposure to environmental noise, particularly in urban areas, and well-documented scientific evidence of the exposure-response relationship between this exposure and annoyance responses (eg Miedema and Vos, 1998) the reliance on "annoyance" as a sole criterion for assessment has been a limitation.

Firstly, at a political and decision-making level, "annoyance", no matter how good the science of its measurement and assessment has been, has not been able to gain traction—it appears not to be able to convince in terms of the nature of the environmental noise problem, the magnitude of its effects on people's quality of life and well-being, nor the proportion of the population affected.

While project-based EA may satisfactorily make comparisons of the extent of noise annoyance between, say, alternative alignments of a road scheme, the use of annoyance as the yardstick beyond project-based assessments is problematic. It is a weak measure to apply at strategic level assessments because of its failure to gain political traction. How likely would it be, for example, based on a strategic level assessment, that a policy-maker would readily be convinced to take action on noise, or to allocate resources for its management, when the assessment of a policy or plan identifies trade-offs, say between the extent of death and disability from road accident traumas; the mortality and morbidity caused by particulate matter exhausted from road transport; and the proportion of the population highly annoyed with noise?

Thus while noise annoyance can already be incorporated within Strategic Environmental Assessments of instruments such as policies in urban consolidation, programs of road pricing and/or regional land use plans, it is unlikely, to impact outcomes. The consideration of noise at a policy level as a problem with specific health outcomes has thus been limited (de Hollander et al., 1999).

This situation has now changed significantly, with the World Health Organisation recently publishing methodology and estimates of the burden of disease for environmental noise.

BURDEN OF DISEASE FROM ENVIRONMENTAL NOISE

In recent years, evidence has accumulated regarding health effects of environmental noise. In order to inform future policy, and to develop management strategies and action plans for its control, national and local governments need to understand and consider this new evidence on health impacts of environmental noise, and to gain experience in its application, particularly in Strategic Environmental Assessment (SEA) of plans, policies and programs that potentially alter population exposure to environmental noise.

Quantitative estimation of the burden of disease due to environmental noise (EBD) requires a risk assessment approach—the identification of hazards, the assessment of population exposure and the determination of appropriate exposure-response relationships. The EBD is expressed in the metric Disability-Adjusted Life Years, DALYs (Murray, 1996) which sums the potential years of life lost due to premature death (YLD) and the equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability (YLL).

WHO has estimated the global burden of disease (BOD) (Murray et al., 1996), and additionally the EBD of disease (that due to environmental factors such as outdoor and indoor air pollution, poor water supply and sanitation etc) (WHO, 2002). It has now extended this EBD methodology to environmental noise.

Over the last five years, the WHO European Centre for Environment and Health, Bonn organized meetings of experts to examine the current state of knowledge, and to further develop approaches for quantifying the effect of noise on health. The outcome is a guidance document on the health effects of environmental noise—quantitative risk assessments based on Environmental Burden of Disease methodology and the metric Disability-Adjusted Life Years (DALY). This has recently been published (Fritschi et al., 2011). The document has been prepared with a European focus in terms of policy, available data, and legislation—and with an emphasis on the noise from road transport sources. However, if the assumptions, limitations and uncertainties described in the document are taken into account, the processes of risk assessment illustrated can also be applied outside Europe.

The following health endpoints of environmental noise are included in the EBD estimation:

- cardiovascular disease
- cognitive impairment
- sleep disturbance
- annoyance
- tinnitus.

The target audience is primarily policy makers, their technical advisers and staff from supporting agencies, and other stakeholders who need to estimate the effects of environmental noise. The document brings together evidence-based information and provides guidance as to how to quantify these effects. It provides: guidance for the procedure of health risk assessment of environmental noise; synthesized reviews of evidence on the relationship between environmental noise exposure and health effects; exemplary estimates of burden of the health impacts of environmental noise based on established exposure-response relationships, exposure distribution, background prevalence of disease, and disability weights; and a discussion of uncertainties and limitations of the EBD procedure, which lead to challenges still to be resolved.

Estimation of DALY for a health outcome of noise exposure requires:

- clearly defining each health outcome, including a summary review of the evidence linking noise with that outcome, including biological models of causation where appropriate, relevant experimental and epidemiological studies, methods of measurement of the outcome and appropriate noise exposure indicators,
- the distribution of the exposure to environmental noise within the population (prevalence of noise exposure). There has been a focus on road traffic noise for several estimates as the best data are available for this source. Sources of noise such as neighbourhood and industrial noise still need better characterisation and estimation,
- the exposure-response relationship for the particular outcome, usually obtained from epidemiological

studies. The validity of any exposure-response relationship depends on the quality of the studies used to derive it (including meta analyses where used), the choice of studies used, and how well specific age or gender groups have been represented,

- a population-based estimate of the baseline incidence or prevalence of the outcome from surveys or routinely reported statistics
- a value of disability weight for each health outcome that allows non-fatal health states and deaths to be measured under a common currency. Disability weights allow time lived in various health states to be valued and quantified. Disability weights that are commonly used for calculating disability adjusted life years (DALYs) are measured on a scale of 0 to 1 where 1 represents death and 0 represents ideal health. Each chapter indicates the source of the disability weights used for each outcome.

The Fritschi et al. (2011) document brings together the best literature and available data and provides well-argued and transparent justifications for the estimates made.

By applying this methodology, the WHO document reports estimates that: "*… DALYs lost from environmental noise in the EU countries are 60 000 years for ischaemic heart disease, 45 000 years for cognitive impairment of children, 903 000 years for sleep disturbance, 21 000 years for tinnitus and 587 000 years for annoyance. Sleep disturbance and annoyance mostly related to road traffic noise comprise the main burdens of environmental noise in western Europe. If all of these impacts are considered together, the interval estimate would be 1.0–1.6 million DALYs. The total burden of health effects from environmental noise would be greater than one million years in western Europe, even with the most conservative assumptions that avoid any possible duplication.*"

APPLICATION IN STRATEGIC ENVIRONMENTAL ASSESSMENT

The WHO document (Fritschi et al., 2011) provides one of the first systematic estimations of the burden of disease for various health endpoints caused by environmental noise. The disability-adjusted life years (DALYs) lost through environmental noise exposure are calculated for cardiovascular diseases in adults, cognitive impairment in children, sleep disturbance, annoyance, and tinnitus. The Environmental Burden of Disease process, as applied by WHO, is one way of synthesizing this evidence in a standardized manner that provides a useful starting point in providing policy-makers with quantitative estimates of health risk of noise and, particularly important, provides this in terms other than "annoyance" – currently the sole criterion for much assessment.

Given the nature of the evidence on which the estimation of the health effects of environmental noise are based (large scale data sources, multi-study and multi-country estimates of exposure-response, etc) examination of the health effects of noise in this way is unlikely to be suitable for project-based EA. However the availability of such quantitative assessments of the burden of disease from environmental noise means that noise can now be appropriately considered at the strategic level, quantifying in the common unit of DALYs, the consequences of different alternatives within the development of strategic levels activites. These could include, amongst many others: regional/national transport plans and policies; urban and regional plans; and the development of policy settings such as preferred form of urban development or congestion pricing. The magnitudes of the EBD for road transport, as illustrated in the previous section, warrant the inclusion of noise in the health assessment of such policies and plans. The EBD for noise will likely rank, in many SEA, alongside similar estimates for the health impact of other matters such as road vehicle accidents and atmospheric pollution. Further, there is some evidence that, while the EBD for other effects may be dropping over time, that for environmental noise may be increasing.

Formulating effective policy and planning measures in the future can be supported by estimates of the burden of disease caused by environmental noise within Strategic Environmental Assessments.

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