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ARE THE BENEFITS OF MODERN TRANSPORT OUTWEIGHED BY THE HEALTH EFFECTS CAUSED BY ITS NOISE?

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1. INTRODUCTION

"Health is a state of complete physical and social well-being, and not merely the absence of disease or infirmity."[1]

Modern society has benefitted from modern technology, especially modern transportation. We have effectively shrunk the globe to permit travel in hours that would previously have taken days, weeks or even months. However, the cost of this benefit is an alteration of the noise climate; there is no area of the world that is now immune to man-made noise. We know that workplace noise exposure can be harmful to a worker's hearing. There is an increasing public perception that environmental noise may be harmful to those who are exposed to it, which is driving a lobby to reduce environmental noise exposures as far as possible. Before limits are set to reduce noise exposure it is essential that the rationale behind the proposed limits is accepted; introducing limits will be costly both financially and, potentially, to our lifestyle. In short, health-based limits should be based on credible scientific and medical evidence, and due consideration should be given to balancing the potential effect on 'infirmity' against the potential effect on 'social well-being'.

2. RESEARCH METHODS

When considering health effects that may be linked to noise exposure it is important that the research method used is chosen carefully so that the validity of the results is unquestionable. The problem with most research methods used in noise and health research is that they can only show an association, or INFERENCE, not CAUSE. This is because the normal research method chosen is the cross-sectional epidemiological study. These studies are useful when testing a hypothesis that effect X may be linked to input Y. However, because the study only looks at the population at a single point in time it is not possible to say the effect was caused by the input. A method to strengthen the association between input and effect is to perform a meta-analysis on a series of studies that have similar methods. Such meta-analyses have been done in some noise and health research, predominantly research into the cardiovascular effects of noise. The indications are that there is an association between noise and raised blood pressure, but the system still does not prove CAUSE.

A research method which has been much used in the past, but which seems to have fallen out of favour, is the laboratory study. Of necessity, laboratory studies start from a single hypothesis and set an experiment to test the validity of that hypothesis. For example, if considering the hypothesis that aircraft overflight noise was responsible for a major rise in blood pressure, you may consider exposing a subject to a recording of typical aircraft noise whilst they were linked to machines that monitored their heart rate and their blood pressure. Ethical clearance would be needed before such a study could be done and, arguably, it is unethical to do such an experiment if you believe that the rise in blood pressure is harmful to the subject's health. Laboratory studies are also open to the criticism that they do not measure typical outcomes because the effect on the 'man in the lab' is different to the effect on the 'man in the street'. However, I believe that there is scope to undertake a limited number of laboratory studies to clarify some of the associations that are reported in epidemiology. Moreover, it may be sensible to overcome the 'man in the lab' phenomenon by establishing a pseudo-laboratory in a study subject's own home.

The best test method to show whether a particular health effect is linked to a particular noise dose is the prospective longitudinal epidemiological study. One problem with such a study is that it takes many years before the results can be reported. The benefit, however, is that this study method will usually prove CAUSE. Occasionally, people will use a retrospective study or a case-control study. Both of these methods are better than cross-sectional studies but, like them, they show only association not cause. The major problem with undertaking a prospective study is the cost. However, in the noise field there are additional uncertainties which can make the prospective study unfeasible. These uncertainties are:

Measuring the Existing Exposure to Noise. It is very difficult to obtain accurate noise doses for each individual in the study population over a period of years.

Projection Into the Future. Not only is it difficult to measure current exposure accurately, it is even more troublesome to project what the noise exposure may be in the future.

Environmental v Personal Dose. Measurement of the environmental dose is relatively easy with a static monitor. However, it is not possible to relate an outside dose to an individual who will be moving around the area. Furthermore, the individual may well spend much of the time in an area where the noise is attenuated. Moreover, it is potentially expensive to service a noisemeter for the duration of the study.

Individual Susceptibility. Different people react differently to the same dose of noise. In fact, the same person may give a different response to the same dose at a subsequent exposure on the same day.

Other Noise Sources. Clearly, where the research project is to identify if a particular type of noise, for example transport noise, causes a particular health effect, then it is necessary to eliminate all other sources of noise. Other factors may also confound the results of the study, most notably, socio-economic factors.

3. CLINICAL SIGNIFICANCE

In health research it is normal to investigate a number of different physiological parameters, for example blood pressure, steroid levels or fats. Obviously, hearing threshold levels, and changes thereto, are frequently measured. There is no doubt that exposure to noise damages hearing. However, the dose of noise needed to damage hearing may be quite high and is usually only reached in an occupational noise exposure. In all cases it is essential, in the author's opinion, to balance the measurable physiological outcome against the clinical significance of that outcome before claiming the result as a health effect. For example, one researcher has published data that indicates hearing may be damaged by noise exposure in the 15kHz range. However, very few individuals clearly hear at 15kHz - this range is the province of bats! Accordingly, there is very little clinical effect from this finding; always assuming that the finding is indeed scientifically valid.

Another area where findings are regularly attributed to noise is cadiovascular effects, particularly a rise in blood pressure. Many research studies indicate that exposure to noise is associated with a few millimetres of increased systolic blood pressure. Other things which can cause similar rises in blood pressure are laughing, coughing and even straining. Unless these natural bodily reactions have been excluded they will confound the results of epidemiological studies and give falsely high results. Moreover, there is little evidence to show that numerous small rises in blood pressure (which returns to normal once the provoking stimulus passes) eventually leads to significant medical effect, such as permanent hypertension. Furthermore, the fact that the mechanism for such blood pressure rises seems to be different in subjects whose parents had high blood pressure from the mechanism in people who were previously normotensive casts doubt on the clinical significance of the findings.

4. HEALTH EFFECTS

The health effects attributed to noise exposure may be divided into a number of different categories. The effects of occupation on hearing have been well documented over many years. The Noise at Work Regulations set exposure limits which were a balance between protecting the hearing of the workforce and economic ability to limit the noise dose. The current legal exposure dose of 90dB(A) is set at a point where up to 4% of the workforce will be 'deafened' after a full working life exposure. Loud noise of rapid onset and short duration - impulse noise - may produce unpredictable threshold shift effects. In addition, it is known that exposure of drop-forge workers to repeated impulsive type noises of about 135dB gave 70% of the workforce tinnitus after about 10 years exposure, compared with only 3% of the control group[2]. It has been postulated that some aircraft overflight noise may also be impulsive in nature, and thereby more damaging, albeit overflight noise is not defined as impulsive noise by current international agreement. Furthermore, it is agreed that onset rates below 60dB/s[3] and levels below 125dB(A) max[4] are unlikely to cause hearing damage.

Extra-auditory health effects associated with noise may be considered under a number of headings: Foetal, Childhood, Psychiatric, Hormonal and Cardiovascular.

Foetal. Possibly the most emotive effects are those that could influence the outcome of pregnancy. The major research study in this area looked at the birth weight of babies born to parents living under the approach path to a major international airport. They found the study group babies were a few grams lighter than the average weight of babies born to parents who lived in quieter areas. Quite apart from the other possible environmental and socio-economic confounding factors that may account for this different, even without the noise there may be no clinical significance to the result. Normal individual differences in humans leads to a large normal range of birth weights. Without evidence, that can only come in the future, that this reduction of weight has a significant effect on growth and/or life expectancy, it is questionable whether the factor should be deemed a health outcome. Furthermore, research into pregnancy outcomes of mothers exposed to occupational noise revealed no differences[5].

Childhood. There have been a number of recent research projects looking at the effects of noise on children's learning abilities. In 1981, Cohen et al looked at schools in Los Angeles. Their implied effects from a cross-sectional study were not supported by analysis from ongoing longitudinal study[6]. Furthermore, the results of a study in New York published by Evans and Maxwell in 1997 found the opposite effects to the LA work[7]. Stansfield's work around Heathrow was confounded by the 'school effect' and generally inconclusive[8]. Even Hygge's research round the change of airport in Munich, though generally reported to show a detriment to the learning abilities of children in the noisy areas with an improvement in the worst affected area after the old airport closed, may be explained by the 'school effect' or even 'test effect'[9].

Psychiatric. Effects on the psyche are most likely in those who are annoyed by the noise[10]. McLean[11] described the typical noise sensitive person as being "well-to-do, middle-aged, intelligent though suspicious of modern technology, aware of the environment and social problems, afraid of aircraft, concerned with their health and high scorers on indices of neuroticism". EEG responses are greater when the individual perceives the noise as unpleasant[12]. Overall, linkage of psychological effects to noise is highly complex, with much scope for confounding factors. Noise may well be the 'last straw' in a number of social and environmental factors that precipitate a measurable outcome, not the causative factor.

Hormonal and Cardiovascular. The most commonly reported effect on the circulation is a rise in blood pressure, which has been described earlier. Whether repeated rises in blood pressure has a long term detrimental effect is equivocal and would need much research, but, noise is certainly not the major cause of these pressure changes. Hormonal changes described include rises in the levels of adrenaline and nor-adrenaline - the 'fight-or-flight' response. Such changes would be expected following exposure to any stressor. In addition, increases in cortisol have been reported, but it is notoriously difficult to get an accurate assessment of this steroid under 'normal' circumstances; any anxiety causes the hormone level to rise rapidly[13].

5. LIMIT SETTING

Many efforts have been made to set limits for noise exposure that will allow a healthy environment. Proposed limits may be set according to one of 2 schools; based on a 'no observable effects' threshold, or based on an 'acceptable risk' threshold. Fortunately for scientists, choice of limit is a political decision! The Netherlands Health Council Report in 1994 attempted to identify threshold levels of noise exposure where physiological effects could be expected. Such work could be used as a basis for setting a health based limit. However, in common with Occupational Exposure Limits, it is prudent to add a safety margin to the limit; in Occupational Medicine a factor between 2 and 10 is arbitrarily applied. Accordingly, if limits are set using the Netherlands Health Council Report's lowest threshold effect level (SEL of 35dB indoors for sleep disturbance) then even without a safety margin all transport noise will have to be dramatically reduced. In consequence, many existing transport systems may need to be relocated or closed. Such a low limit may protect 'physical' health but could be 'unhealthy' by impinging on WHO's defined 'well-being' clause - possibly preventing the individual using transport from home to job, or even having a job to go to!

Common sense should be applied when setting limits and it is suggested that the time is now right to begin balancing the debate. To inform the debate, more research is needed but it is further suggested that rather than more cross-sectional epidemiological studies it may be more appropriate to fund more focused laboratory or pseudo-lab work to identify specific health effects. The trouble with any epidemiological study, however powerful, is that if the effect is small and/or the number if individuals who are susceptible to the effect is small, then the study will be inconclusive - those suffering the effect are likely to become confused within the extremes of the normal distribution curve[14]. Therefore, it is suggested that the best way forwards for future noise research is to attempt to identify which individuals are vulnerable to the effects of noise[15]. The author does not believe that specific groups, like children or the elderly, are vulnerable, but that certain individuals across the age spectrum may be. In essence, can McLean's work be extended to identify the characteristics of a vulnerable or susceptible individual. Then if such individuals can be identified, how can their exposure be limited to protect them? It is suggested that this will not be easy but it is the only proper way to react to an identified health effect.

6. CONCLUSION

As yet, the benefits of modern transport are not outweighed by the possible noise effects on health. But, we have a responsibility to ensure that the cost-benefit analysis is undertaken and revised frequently in the light of new evidence. Furthermore, it is science's responsibility to inform the legislators of potential health effects in a manner which is both balanced and credible, without allowing any personal bias to skew the advice offered. Lastly, any limits proposed must encompass the 'personal well-being' aspect of the health of the population - their right to have work and enjoy their leisure - as well as the effects on measurable physiological variables which may or may not have a clinical significance.

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