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Noise and Non-Auditory Health Effects in Children

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ABSTRACT

Non-auditory effects of noise involve effects on health and well-being which are caused by exposure to noise, with the exclusion of effects on the hearing organ and the effects which are due to the masking of auditory information (i.e. communication problems). Exposure to continuous noise of 85-90 dBA, particularly over a lifetime in industrial settings, can lead to a progressive loss of hearing, with an increase in the threshold of hearing sensitivity. This paper therefore assessed noise and the non-auditory health effects in children. It presents that the evidence for effects of environmental noise on health is strongest for annoyance, sleep and cognitive performance in children. It may be that the risk of developing mental or physical illness attributable to environmental noise is quite small, but it is too soon to be certain of this, partly because, the interaction between people, noise and ill-health is a complex one. Humans are not usually passive recipients of noise exposure and can develop coping strategies to reduce the impact of noise exposure. Hence, there is a need for further research to clarify this complex area, including better measurement of noise exposure and health outcomes.

Keywords: Noise, Auditory, Children, Health, Communication.

INTRODUCTION

Non-auditory effects of noise involve effects on health and well-being which are caused by exposure to noise, with the exclusion of effects on the hearing organ and the effects which are due to the masking of auditory information (i.e. communication problems). Exposure to continuous noise of 85–90 dBA, particularly over a lifetime in industrial settings, can lead to a progressive loss of hearing, with an increase in the threshold of hearing sensitivity [1]. Hearing impairments due to noise are a direct consequence of the effects of sound energy on the inner ear. However, the levels of environmental noise, as opposed to industrial noise, are much lower and effects on non-auditory health cannot be explained as a consequence of sound energy. It is generally believed that noise disturbs activities and communication, causing annoyance. In some cases, annoyance may lead to stress responses, then symptoms and possibly illness [2]. Alternatively, noise may influence health directly and not through annoyance. The response to noise may depend on characteristics of the sound, including intensity, frequency, and complexity of sound, duration and the meaning of the noise.

Non-auditory effects of noise on health

Noise and sleep disturbance: There is both objective and subjective evidence for sleep disturbance by noise. Exposure to noise disturbs sleep proportional to the amount of noise experienced in terms of an increased rate of changes in sleep stages and in number of awakenings. Habituation occurs with an increased number of sound exposures by night and across nights. One laboratory study, however, found no habituation during 14 nights of exposure to noise at maximum noise level exposure [3]. Objective sleep disturbance is likely to occur if there are more than 50 noise events per night with a maximum level of 50 dBA indoors or more. In fact, there is a low association between outdoor noise levels and sleep disturbance. In the Civil Aviation Authority Study [4] around Heathrow and Gatwick airports, the relative proportion of total sleep disturbance attributable to noise increased in

noisy areas but not the level of total sleep disturbance. In effect, the work suggested a symptom reporting or attribution effect rather than real noise effects. In a subsequent actigraphy study around four UK airports, sleep disturbance was studied in relation to a wide range of aircraft noise exposure over 15 consecutive nights [5]. Although there was a strong association between sleep EEGs and actigram-measured awakenings and self-reported sleep disturbance, none of the aircraft noise events were associated with awakenings detected by actigram and the chance of sleep disturbance with aircraft noise exposure of some adaptation to sleep disturbance by noise, complete habituation does not occur, particularly for heart rate.

Noise exposure and performance: There is good evidence, largely from laboratory studies, that noise exposure impairs performance. Performance may be impaired if speech is played while a subject reads and remembers verbal material, although this effect is not found with non-speech noise [6]. The effects of 'irrelevant speech' are independent of the intensity and meaning of the speech. The susceptibility of complex mental tasks to disruption by 'irrelevant speech' suggests that reading, with its reliance on memory, may also be impaired. Perceived control over and predictability of noise has been found to be important in determining effects and after-effects of noise exposure. Glass and Singer [7] found that tasks performed during noise were unimpaired but tasks that were carried out after noise had been switched off were impaired; this being reduced when subjects were given perceived control over the noise. Indeed, even anticipation of a loud noise exposure in the absence of real exposure may impair performance and an expectation of control counters this effect. Noise exposure may also slow rehearsal in memory, influence processes of selectivity in memory, and choice of strategies for carrying out tasks. There is also evidence that noise may reduce helping behaviour, increase aggression and reduce the processing of social cues seen as irrelevant to task performance [8].

Noise exposure and psychological symptoms: Symptoms reported among industrial workers regularly exposed to high noise levels in settings such as schools and factories include nausea, headaches, argumentativeness and changes in mood and anxiety. Many of these industrial studies are difficult to interpret, however, because workers were exposed to other stressors such as physical danger and heavy work demands, in addition to excessive noise. Community surveys have found that high percentages of people reported 'headaches', 'restless nights', and 'being tense and edgy' in high-noise areas [8]. An explicit link between aircraft noise and symptoms emerging in such studies raised the possibility of a bias towards over-reporting of symptoms [9].

Noise and common mental disorder

Early studies found associations between the level of aircraft noise and psychiatric hospital admission rates both in London and Los Angeles, but this has not been convincingly confirmed by more recent studies. In community studies such as the West London Survey of Psychiatric Morbidity [10], no overall relationship was found between aircraft noise and the prevalence of psychiatric morbidity using various indices of noise exposure. In longitudinal analyses in the Caerphilly Study, no association was found between road traffic noise and psychiatric disorder, even after adjustment for socio-demographic factors and baseline psychiatric disorder, although there was a small non-linear association of noise with increased anxiety scores [11]. Some studies have found dose–response associations: exposure to higher levels of military aircraft noise around Kadena airport in Japan was related in a dose–response relationship to depressiveness and nervousness [12], and road traffic noise has been weakly associated with mental health symptoms after adjusting for age, sex, income and length of residence [13]. Overall, environmental noise seems to be linked to psychological symptoms but not to clinical psychiatric disorder. However, there may be a link to psychiatric disorder at much higher noise levels.

Noise annoyance

The most widespread and well documented subjective response to noise is annoyance, which may include fear and mild anger, related to a belief that one is being avoidably harmed [14]. Noise is also seen as intrusive into personal privacy, while its meaning for any individual is important in determining whether that person will be annoyed by it. Annoyance reactions are often associated with the degree of interference that any noise causes in everyday activities, which probably precedes and leads on to annoyance [15]. In both traffic and aircraft noise studies, noise levels have been found to be associated with annoyance in a dose–response relationship [16]. Overall, it seems that conversation, watching television or listening to the radio (all involving speech communication) are the activities most disturbed by aircraft noise while traffic noise, if present at night, is most disturbing for sleep.

Acoustic predictors of noise annoyance in community surveys

One of the primary characteristics affecting the unwantedness of noise is its loudness or perceived intensity. Loudness comprises the intensity of sound, the tonal distribution of sound and its duration. The evidence is mixed on the importance of both the duration and the frequency components of sound and also the number of events involved in determining annoyance [17]. High frequency noise has been found to be more annoying than low frequency noise. Vibrations are perceived as a complement to loud noise in most community surveys of noise and are found to be important factors in determining annoyance, particularly because they are commonly experienced through other senses as well as hearing. Fields [18] found that, after controlling for noise level, noise annoyance

increases with fear of danger from the noise source, sensitivity to noise, the belief that the authorities can control the noise, awareness of the non-noise impacts of the source and the belief that the noise source is not important.

Noise and Non-Auditory Health Effects in Children

It is likely that children represent a group which is particularly vulnerable to the non-auditory health effects of noise. They have less cognitive capacity to understand and anticipate stressors and lack well-developed coping strategies [19]. Moreover, in view of the fact that children are still developing both physically and cognitively, there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group. Cognition Studies of children exposed to environmental noise have consistently found effects on cognitive performance. The studies which are most informative in terms of the effects of noise on cognition have been field studies focusing on primary school children. The effects of noise have not been found uniformly across all cognitive functions. The research evidence suggests that chronic exposure to noise affects cognitive functions involving central processing and language comprehension.

The effects which have been found can be summarized as follows: Deficits have been found in sustained attention and visual attention [20]. Relatedly, according to teachers' reports, noise-exposed children have difficulties in concentrating in comparison with children from quieter schools [21]. Children exposed to chronic environmental noise have been found to have poorer auditory discrimination and speech perception [19], as well as poorer memory requiring high processing demands. Finally, chronically exposed children tend to have poorer reading ability and school performance on national standardized tests [22]. The first well-designed naturalistic field study to examine the effects of chronic noise exposure focused on primary school children living in four 32-floor apartment buildings adjacent to a major road [23]. The rationale behind this study was that children in the lower floor of the apartment building would be exposed to higher amounts of noise from the road than those higher up the building. Seventy-three children were tested for auditory discrimination and reading level and the results indicated that children living on the lower floors had greater impairments on these measures than those living higher up the buildings. A very well controlled study by Bronzaft and McCarthy [25] compared primary school children taught in a classroom which was exposed to high levels of railway noise with children in a quiet classroom in the same school. Significant differences in reading scores were found between children in the two classrooms. In fact, the mean reading age of the noise-exposed children was 3–4 months behind that of the control children. A series of studies have been carried out in schools around Heathrow Airport in west London. These studies have used repeated-measures designs to compare noise-exposed and control children. In the first of these studies [26], the cognitive performance and stress responses of 9- to 10-yearold children in four high noise schools were compared with those of children in four matched control schools. The results showed that, at baseline, the noise-exposed children had impaired reading comprehension and sustained attention after adjustment for age, main language spoken at home and social deprivation. The results at follow up 1 year later suggest that the children's further development in reading comprehension may be affected. The second study to be conducted near Heathrow Airport [27] was a multi-level modelling study of national standardized test scores (SATs). The data for 11,000 eleven-year-old children were analysed in relation to aircraft noise exposure contours. The results showed that noise exposure was associated with performance on reading and maths tests in a dose– response function but that this was influenced by socio-economic factors. The most recent study to be carried out at Heathrow [28] compared the cognitive performance and stress responses of children in 10 high-noise schools with those of children in 10 matched control schools. The results indicated that children in the noise-exposed schools experienced greater annoyance and had poorer reading performance on the difficult items of a national standardized reading test.

Perhaps the most important of all the naturalistic field studies to examine the effects of noise exposure on children was that carried out in Munich in the 1990s. This prospective, longitudinal study was able to take advantage of a naturally occurring experiment in which the existing Munich Airport was closed down and a new airport was opened at another location. Data were collected at both sites across three testing waves, one before the closure of the old airport and opening of the new one and two afterwards. The mean age of children was 10.8 years. The cross-sectional results [22] showed that, at Wave 1, children at the old airport displayed effects on long-term episodic memory and reading comprehension. The longitudinal results [29] showed that after three waves of testing, children at the old airport had improvements in long-term memory, suggesting that this effect of noise exposure is reversible. Interestingly, by the third wave of testing children at the new airport were exhibiting deficits in long-term memory and reading comprehension, providing strong evidence for a causal link between noise exposure and cognitive effects.

Motivation

A number of studies have identified an association between chronic exposure to aircraft noise and decreased motivation [24]. The results are however not consistent. In the Los Angeles Airport Study, children exposed to chronic aircraft noise were less likely to solve a difficult puzzle involving a success or failure experience and were more likely to give up. In a follow-up 1 year later, the finding that noise-exposed children were less likely to solve a

difficult puzzle was replicated, but the finding that the same children are more likely to give up on a difficult puzzle was not. In the Munich study [22], noise-exposed children gave up on an insoluble puzzle more quickly than their non noise-exposed counterparts.

Cardiovascular effects

In addition to effects on cognitive performance, there is evidence that chronic noise exposure may give rise to physiological effects in terms of raised blood pressure. In the Los Angeles Airport Study [24], chronic exposure to aircraft noise was found to be associated with raised systolic and diastolic blood pressure. These increases, although significant, were within the normal range and were not indicative of hypertension. At follow-up 1 year later [28], the findings were the same, showing that these effects had not habituated. In the Munich study, chronic noise exposure was found to be associated with both baseline systolic blood pressure and lower reactivity of systolic blood pressure to a cognitive task presented under acute noise. After the new airport opened, a significant increase in systolic blood pressure was observed providing evidence for a causal link between chronic noise exposure and raised blood pressure. No association was found between noise and diastolic blood pressure or reactivity.

Noise annoyance

Studies have consistently found evidence that exposure to chronic environmental noise causes annoyance in children, even in young children [20, 25, 26, 27, 28]. In Munich, noise-exposed children were found to be more annoyed by noise as indexed by a calibrated community measure. In London, child adapted, standard self-report questions [18] were used to assess annoyance and showed higher annoyance levels in noise-exposed children. In a follow-up 1 year later, the same result was found, suggesting that annoyance effects are not subject to habituation.

CONCLUSION/RECOMMENDATION

The evidence for effects of environmental noise on health is strongest for annoyance, sleep and cognitive performance in children. It may be that the risk of developing mental or physical illness attributable to environmental noise is quite small, but it is too soon to be certain of this, partly because, the interaction between people, noise and ill-health is a complex one. Humans are not usually passive recipients of noise exposure and can develop coping strategies to reduce the impact of noise exposure. Hence, there is a need for further research to clarify this complex area, including better measurement of noise exposure and health outcomes.

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