

—Review—

The Effect of Noise on the Health of Children

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Abstract

The effects of noise on health, especially that of children, were reviewed.

(1) From the point of view of disturbance of daily living, subjective recognition of “noisiness” is an important issue in relation to the study of noise. Concerning the effects of airplane noise on school children, while no effects on the hearing level were detected, a significant increase in the complaint of “noisiness” was observed.

(2) Exposure of pregnant women to airplane noise was found to be associated with a decrease in the body weight of newborn babies. Moreover, the height of 3-year-old boys and girls was found to be significantly decreased in association with increase in the environmental noise.

(3) Noise levels that seemed to have some influence on the sleep of adults did not affect the sleep of children.

(4) In a group of children living in noisy districts exhibiting poor academic performance, the academic performance seemed to become progressively worse as the school grade advanced.

(5) No consensus has been arrived at in regard to headphone-induced hearing impairment.

Researches and studies effective enough to influence policy decisions must be continually conducted in the future, with appropriate control for related factors.

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Key words: noise, health effect, children

Introduction

“The Effects of Noise on Man,” written by Karl D. Kryter is regarded as a bible on the effects of noise in humans. The first edition of this book was published in 1970, and the second edition, in 1985. Although the book was published under a changed title in 1994, it was essentially regarded as the third edition¹. It takes a tremendous amount of effort for an author to compile a technical book of over 600 pages by himself. The sections comprising this book are well-balanced, and the descriptions are non-

redundant and consistent.

What is noise?

According to the JIS-Z8106 Acoustic Terminology <General>, noise is defined as “sound that interferes with communication of voice or music, and sound that causes pain or disorder in the ears.” In other words, it is a term used to refer to “unwanted sound,” in general. Noise is closely related to various activities of daily living, such as communication, studying, thinking, and sleep. During the past several years, claims made for noise pollution have

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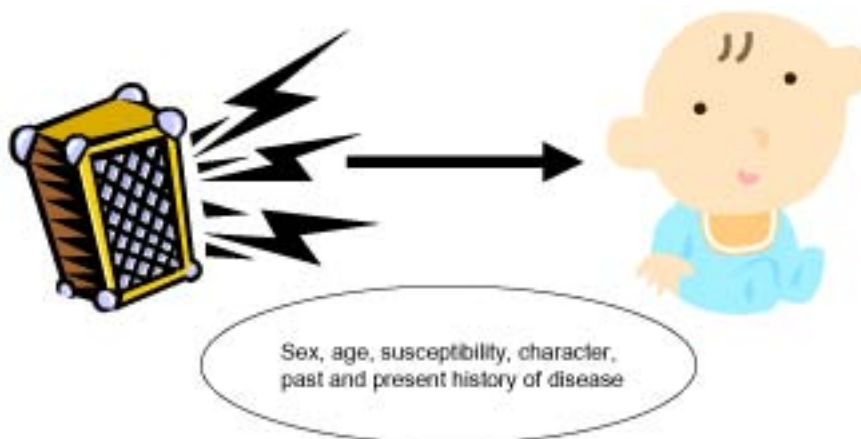


Fig. 1 Factors modifying the effect of environmental noise on health of children

ranked at the top in terms of the number of claims for pollution.

School buildings facing national highways often take anti-noise measures, such as soundproofing of walls and double-sash windows. In adults, the effects of noise on the body are often affected by various factors that are only remotely associated with the physical properties of sound. For example, the difference in stances between those producing the sound and those who are forced to suffer the noise, such as factory workers and the neighboring residents, is a more important factor than individual differences in the sensitivity to sounds. On the other hand, since psychophysiological insomnia is very rare in small children and children in elementary school, children appear to be more likely to be affected by physiological factors than sociological factors related to sound when compared with adults.

The effects of environmental noise on the hosts (adults and children) seem to be modified by several factors (Fig. 1).

Disturbance of daily living by noisiness

Kryter reported the following data in regard to the prevalence of disturbance of daily living of a general population by airplane noise¹ (Table 1).

Effects on infants and small children

Ando and Hattori² and Knipschild et al.³ reported that the mean body weight of newborn babies born

of mothers living in districts with airplane noise was smaller than that of those born of mothers living in a control district. Ando and Hattori⁴ suggested that this might be because of the lower human placental lactogen level in pregnant women living in noisy districts than in those living in a control district.

A previous report of a study on the effects of environmental noise on the development of 3-year-old children⁵ showed that the height of both boys and girls was significantly decreased in association with increase of the weighted equivalent continuous perceived noise level (WECPNL; used for evaluation of the airplane noise). On the other hand, no significant differences in body weight were observed. When compared with the 10th percentile standard value, however, the incidence of decrease in body height with 79.9 dBA or less was less than 10% in boys, which did not differ from that in the standard population. This suggests that the decrease in the body height of boys cannot be explained by the noise level alone, and this issue remains to be clarified.

Effects on sleep

At the noise level caused by the sonic boom that awoke 70% of people aged between 67 and 72 years, 0% of children aged between 7 and 8 years were awakened. This is probably because the elderly have less deep sleep (orthosleep) than younger people, and therefore awaken more readily [quoted from Reference 1, p. 491].

Griefahn and Jansen⁶ reviewed the awaking or

Table 1 Disturbance of daily living by airplane noise

| Phenomenon | % with occasional complaints of the phenomenon on the left |
|--|--|
| Makes the respondent shudder | 38 |
| Interferes with the sounds of bells and alarms | 43 |
| Disturbs conversation for an average of 34 seconds per hour, with sound increase by about 4 to 5 times | 50 |
| Interferes with reading, mental work, and writing | 65 |
| Causes vibrations of the building, which is annoying | 72 |
| Surprises or upsets the respondent | 90 |
| Interferes with sport activities in the playing field | 91 |
| Interferes with the use of AV equipment | 100 |

In a sound environment where the daytime and nighttime average sound level (*Ldn*) is equivalent to 70 dB, the prevalence according to the duration of disturbance was as follows: during the peak only, 3%; 3 to 30 seconds, 51%; 31 to 60 seconds, 30%; and more than 1 minute, 7%. The above-presented figures were calculated on the basis of these data.

sleep-lightening responses to sound stimulation by sonic booms and airplane noise according to age (3 articles; 26 subjects, 368 nights, 4,428 sound stimulations). It was found that the percentage of those who were 50 years of age and 70 years of age who awoke were 4.1 times and 5.5 times larger, respectively, than the percentage of children who were 10 years of age who were awakened. This result indicates that the elderly are, in general, more sensitive to noise.

Effects on blood pressure

Karagodina et al. [quoted from Reference 1, p. 548] studied school children aged between 9- and 13-years-old in a neighborhood of Moscow Airport, and detected a high frequency of malaise and elevation of blood pressure and pulse among these children, which appeared to be attributable to constant exposure to airplane noise.

Karsdorf and Klappach [quoted from Reference 1, p. 549] revealed that elevation of blood pressure due to traffic noise was observed in association with increase in the noise level, particularly in 9th and 10th graders.

According to Cohen et al.⁷, when the socioeconomic status of the subjects was matched, (1) elevation of the systolic blood pressure was observed in association with increasing number of years of residence in a noisy district, and (2) when examined according to the number of years of residence, the av-

erage blood pressure of residents living in a noisy district was higher than that of those living in a control district. Moreover, it was suggested that children were more susceptible to blood pressure elevation induced by environmental noise than adults. According to the results of the re-examination conducted by Cohen et al. a year later⁸, the blood pressure of the children living in the noisy district was almost the same as that of the children living in the control district. These results suggest that the children had probably become accustomed to the noise. Thus, definitive evidence of elevation of blood pressure in children in association with exposure to noise is still lacking.

Academic performance

In a group of children living in a noisy district (peaks of 90 dBA are observed about 50 times a day) with poor scores (3-grade evaluation) in an achievement test, further worsening of the results in the test was reported in association with advancing grade (Maser et al., quoted from Reference 1, p. 625).

Effects on hearing

(1) What is noise-induced hearing impairment?

Noise-induced hearing impairment is a type of inner-ear hearing impairment that progresses chronically during prolonged exposure to noise. It is characterized by elevation of the hearing threshold at a

Table 2 Values that need to be added to the data according to the older standards in audiometry

| Frequency (KHz) | 1/8 | 1/4 | 1/2 | 1 | 1.5 | 2 | 3 | 4 | 6 | 8 |
|-----------------|-----|-----|-----|----|-----|----|---|---|---|---|
| Adjustment (dB) | 5 | 10 | 10 | 10 | 10 | 10 | 5 | 5 | 5 | 5 |

frequency of 4 kHz in an audiogram (referred to as C5 dip). When the exposure to noise persists, the hearing threshold in the bass range, not only at C5, but also at C4 (2 kHz) and C3 (1 kHz) in an audiogram, also tends to increase. In general, noise-induced hearing impairment may be classified into four stages.

First stage: Temporary buzzing of the ear in the early stage of exposure to noise, but the hearing threshold is not affected.

Second stage: Intermittent buzzing of the ear, but the patient is not aware of hearing impairment. Elevation of the hearing threshold at 4 kHz is noted in the audiogram.

Third stage: After several months or years of exposure to noise, the patient begins to feel some difficulty in hearing conversations or ticking of clocks in the presence of noise, with the result that he/she tends to increase the volume of radio or TV.

Fourth stage: After more than 10 years of exposure to noise, hearing impairment becomes evident. Difficulty in listening to conversations and sound signals, etc. becomes obvious.

Elevation of the audible threshold does not, however, continue indefinitely. When exposure to the same noise level continues for more than 10 years, the permanent threshold shift (PTS) becomes stable. The objective of protection from noise-induced decline of hearing is to minimize the PTS.

(2) Pathology of noise-induced hearing impairment

The following changes have been reported to occur in the ears: (1) degeneration and loss of the outer hair cells, and moniliform changes of the hair of the hair cells in the organ of Corti in the cochlea → (2) degeneration of the intracellular organs within the hair cells → (3) swelling and enlargement of the hair cells → (4) disappearance of the cells.

(3) Acceptable standard for noise to prevent noise-induced hearing impairment

Noise-induced hearing impairment cannot be cured, because it is associated with injury to the organ of Corti. The first step in its prevention is to decrease the environmental noise level. For this purpose, a standard for acceptable noise level has been proposed.

In 1969, the Japan Society for Occupational Health proposed a standard for the acceptable noise level on the basis of data of the temporary threshold shift (TTS) obtained under experimental noise exposure. People with normal hearing were exposed to noise of a certain sound pressure level. Then, on the basis of a hypothesis that the TTS is almost the same as the PTS observed in people who have worked for about 10 years at a workplace having a noise level of almost the same sound pressure level, the PTS was predicted from the TTS.

The acceptable standard was established taking into consideration the daily duration of exposure to the noise and the octave. If this standard is observed, the PTS can be limited to 10 dB or less at the frequency of 1 kHz, 15 dB or less at the frequency of 2 kHz, and 20 dB or less at the frequency of 3 kHz or more.

In Japan, a revision of the standards of audiometry was proposed in 1982 (JIS T 1201). The term "hearing loss" was changed to "hearing level," and the following values were added to the hearing loss values in the old standard to convert them into hearing level values (Table 2).

(4) Specific sources of noise and their effects on hearing

[Airplane]

Green et al.⁹ studied the effects of airplane noise on the hearing level of school children, and reported a weak association between the two. In their study, the noise level was estimated on the basis of the distance of the subjects' residences from the airport.

Chen et al.¹⁰ also observed an association between exposure to noise and the prevalence of noise-induced hearing impairment. On the other hand, Wu et al. conducted a hearing test and a questionnaire survey in 242 sixth-graders in a district exposed to airplane noise and in a control district, and found no significant difference in the hearing level between the two groups; however, the percentage of subjects complaining of “noisiness” of the airplanes differed significantly between the two groups (exposed district, 88%; control district, 12.2%)¹¹.

[*Shinkansen* (Japanese bullet train)]

The increase in noise level associated with increase in the speed of *Shinkansen* is often associated with disturbance of hearing, particularly in school-age children¹². The sensitivity of individual school children to the noise of *Shinkansen* has been reported to be an important factor determining the “noisiness” threshold of children in a background of noise¹³.

[Headphone stereos]

More than 20 years have passed since portable headphone stereos were introduced in Japan. While soon after its launch, the product made a booming impact mainly on the younger generation, it is now commonly used by company employees. From the point of view of the consumers’ health, several reports in Japan and overseas have pointed out the risk of noise-induced hearing impairment with continuous use of headphone stereos; however, definitive evidence is still lacking.

Even in a quiet environment, the peak noise level through headphones may reach 100 dB with some genres of music. It then goes without saying that the noise level through portable headphone stereos in a noisy street or train would be much higher. In addition, during the use of portable headphone stereos, where the auricles are not fully covered, the volume tends to be turned up more, because of sound leaks from the headphone and interference by outside noise, than during the use of the headphones of the overhead type (the type that covers the auricles fully, which is used for listening to music in a room); this results in exposure to even higher noise levels.

In a study conducted previously by the authors among college students, no obvious cases of noise-

induced hearing impairment attributable to the use of portable headphone stereos were detected. Moreover, there were no significant differences in the mean air-conduction hearing levels at various frequencies between a group of regular portable stereo headphone users and a control group. However, the percentage of people with a hearing threshold of 25 to 30 dB or more at 4,000 Hz was significantly higher in the portable stereo headphone users than in the control group¹⁴.

A recent report revealed that a past history of otitis media might be associated with the onset of noise-induced hearing impairment¹⁵, suggesting that it may be a risk factor.

The effects of noise on health are reviewed here, focusing mainly on children. It should be borne in mind that one source of noise is often related to multiple environmental factors. For example, when examining the effects of traffic noise on health, not only the noise, but also the effects of nitrogen monoxide and suspended particles in the air should be taken into consideration. Moreover, recent studies have conducted analyses of the mixed effects of noise and vibration. Related factors are sometimes difficult to control, but they cannot be overlooked when making policy decisions on environmental control. Further studies are awaited.

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