Dose-response relationship between aircraft noise and annoyance around an airport in Japan

Tetsuya Kaneko[1,2] * and Kyoichi Goto[2]

[1] Environmental Health, Kyorin University, Hachiohji-shi, Tokyo, 192-8508, Japan

[2] Aviation Environment Research Center, Airport Environment Improvement Foundation, 1-6-5, Haneda-kuko, 144-0041, Japan

* corresponding author: e-mail: kaneko@kyorin-u.ac.jp

INTRODUCTION

Environmental noise is supposed to be one of the risk factors for ischemic heart disease. The risk is assumed to be raised by some mental stress, so-called distress in this case. The stress is caused by the feeling of annoyance that is conduced by interpretation with individual value. Therefore, the annoyance from environmental noise shows an association with the stress scores measured by psychological scales. On the other hand, the heart disease also has many risk factors for its induction. The physical predisposition such as hypercholesteria or hypertension and the lifestyle including smoking or eating habits are the major risk factors for its onset. Naturally, these individual risk factors cannot be regulated by any environmental noise controls. From a view point of cost-effectiveness for public health, it is important to evaluate the contribution of environmental noise to ischemic heart disease (IHD) induction in contrast with the other individual factors.

Figure 1 shows a correlation between IHD and obesity. The data of 27 countries from 30 OECD members exhibited an evident correlation between the obese population rate and the male mortality rate from IHD (OECD 2005). The maximum mortality rate of Slovak Republic and the maximum obese rate of U.S.A. were both ten times higher than the minimum rates of those in Japan, approximately. The data also said the obese rate in a country correlated with calorie intake per capita. These correlations and the disparity among countries suggest that the daily food intake has a huge impact on the onset of IHD and can make the IHD mortality rate higher up to ten times. Here comes a question how much the impact of environmental noise is.

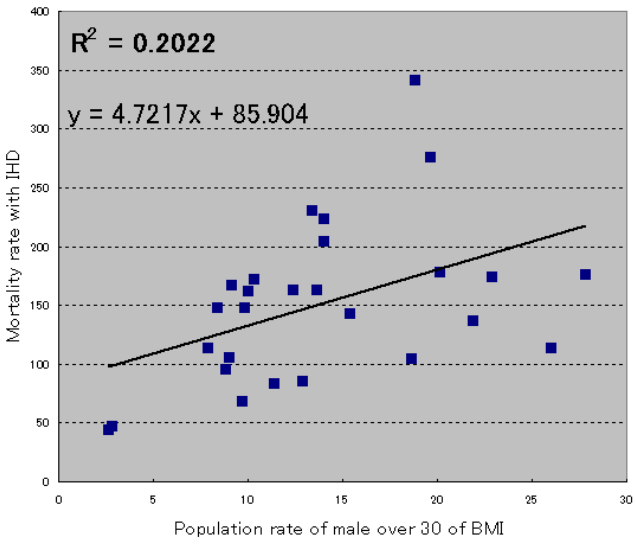


Figure 1: Association between the male mortality rate of ischemic heart disease and the obese population rate among OECD countries. The data for this figure are derived from “Health at a glance: OECD indicators 2005”.

We have conducted a health care support program with free medical examination around three major airports. As a part of the program, some approaches with psychological scales have been also performed from a mental health aspect. From an analysis on the database, we previously reported that the systolic blood pressure showed a significant association not with the aircraft noise level estimated for each residential area, but with annoyance from road traffic noise, though the anxiety correlated with the aircraft noise level (Kaneko & Goto 2006). This suggested that some latent factors were the key to understand these relationships.

Here we show a noise response model with personal factors extracted and combined by analysis of covariance, and suggest that the environmental noise just reveals dormant vulnerability of a highly sensitive group in a population in the noise of a middle range level.

METHODS

Subjects are 894 examinees from 86 communities, around ten persons per community, who received free medical check service, gave us the agreement to join this study and filled - up questionnaire sheet. They were classified into four groups based on the flight noise level estimated for their residential area. Weighted Equivalent Continuous Perceived Noise Level (WECPNL) of Japanese style was used for the estimation. The highest level estimated among the four was 85 dB WECPNL, nearly 72 dB(A) of Ldn. The lowest was under 75 dB of WECPNL (Figure 2).

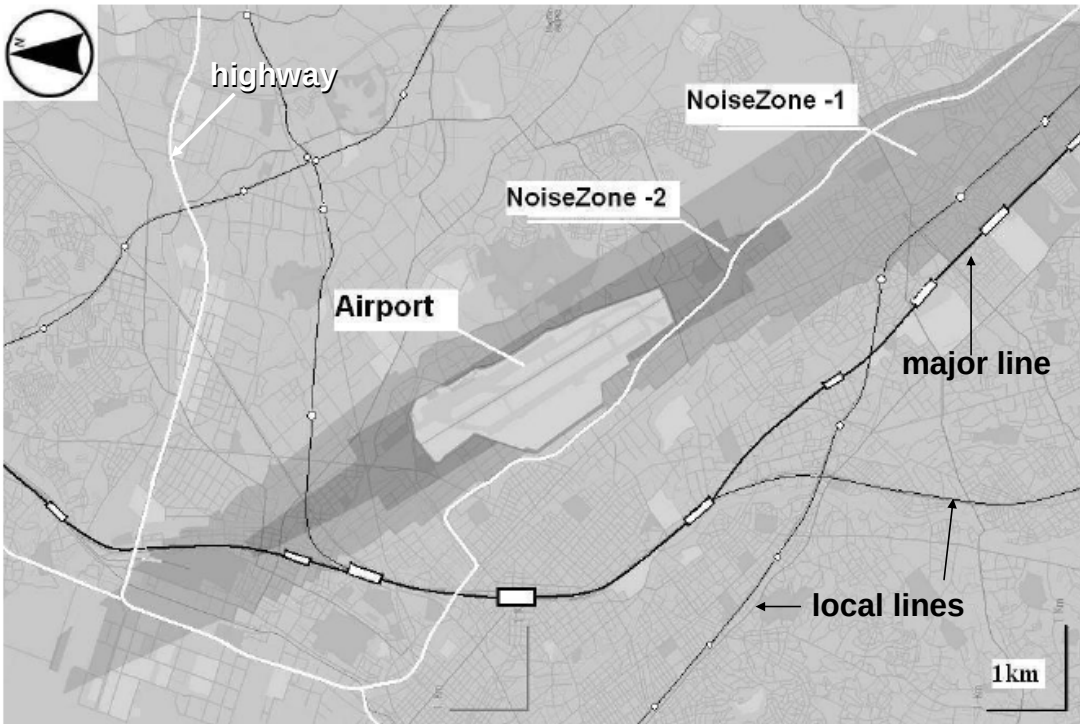


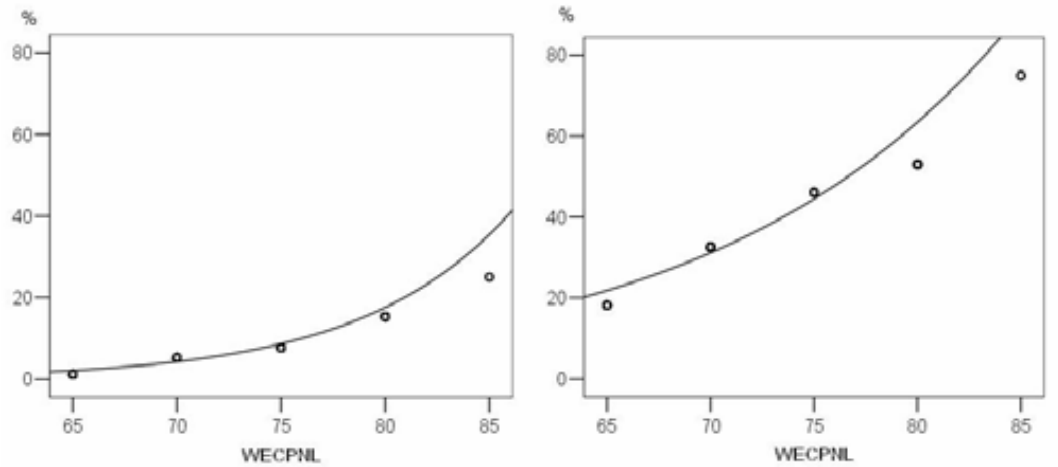
Figure 2: The area for health care service around an airport. The light gray zone indicates Noise Zone 1 where the noise level of WECPNL is over 75 dB and the dark gray zone indicates Noise Zone 2 where the level is over 80 dB. In surrounding area outside the Noise Zone-1 the noise level is estimated under 75 dB. Rectangles and open circles are train stations and dark lines are railroads. White lines mean highways.

Questionnaire was composed of State Trait Anxiety Inventory (STAI, Spielberger et al. 1970), General Health Questionnaire (GHQ) (Goldberg et al. 1988), a verbal annoyance scale against environmental noise (Yano et al. 2004), subjective value scale for circumstances in residential area and some checks on personal lifestyle. STAI can extract the state anxiety as a mental stress apart from the trait anxiety derived from personality. GHQ is widely used to observe a depressive mood as mental stress. The annoyance scale used here consists of five words to evaluate the annoyance of soundscape and of specific noises from several sources including air, road and railway traffic. The obtained data ware analyzed with a package software of statistics, AMOS (version 16) combined with SPSS (version16).

RESULTS

The area holding 86 communities has mainly three traffic noise sources: railway, road traffic and aircraft, however the dominant noise source is the aircraft. This character of the area was confirmed with the fact that the most annoying noise source were reported as the aircraft, and that the proportion of people who chose the top category in five grade annoyance scale, so-called the percent highly annoyed, showed significant association with the aircraft noise level estimated with WECPNL, when they were asked about overall annoyance at home against environmental noise, in other words, a negative value of soundscape.

Figures 3 and 4 show the dose-response relation curves of the percent highly annoyed against aircraft noise, where the subjects were classified into five groups by 5 dB increase of estimated flight noise levels. Figure 3 is for the overall annoyance to environmental noise, and Figure 4 is for the annoyance against aircraft noise. Both responses of annoyance revealed significant association with the noise level (*Kendall* τ test: $p<0.01$), though the response rates against flight noise levels were signifficantlly different between the two. The former resembles the dose-response curve proposed by Schultz (1978) or Finegold (2004), and the latter is comparable to the curve reported by Miedema and Vos (1998). These figures suggest that the response of annoyance from overall environmental noise is different from that from aircraft noise even under the same noise. This gap can be elucidated by assuming that the latter was affected by the psychological image of the noise source, aircrafts.



Figures 3 and 4: Proportion of highly annoyed people and estimated WECPNL in each zone. Figure 3 (left) shows the percent highly annoyed in response to soundscape, and Figure 4 (right) shows the one in response to aircraft noise.

Figure 5 is a path diagram of the result of structural equation modeling based on analysis of covariance. This is the core structure of noise - annoyance - stress relationship in this field. Main indicators signified the fitness of this model. A latent factor that was named vulnerability here showed significantly high correlation with the annoyance from road traffic noise, and low correlation with the annoyance from aircraft noise, but none with an aircraft noise level. The annoyance from railway noise was meaningless in these relations. The score of trait- and state- anxiety were located in this diagram for comparison. Only trait one showed significant correlation with vulnerability directly, however, the state one was suggested to be correlate with that indirectly. The variable of age did negatively correlate with trait-anxiety. The GHQ score was excluded because the data made the fitness of this model worse. GHQ has a medical feature in nature and is so much different from psychological characteristics in STAI. All the medical check data did not exhibit meaningful correlation statistically and were excluded from this path diagram. All the distributions of variables can be considered simultaneously in this analysis, so that the extracted variables and relations are considered to be properly reliable. In other words, the annoyance from traffic noise and the anxiety related with environmental noise were all dominated by a personal inner factor, which was named vulnerability here. And the health indicators such as blood pressure or other medical check data did not exhibit significant correlation with factors illustrated here. These results suggest that an inner personal factor has the dominant role on the noise annoyance and stress relating matters in the middle range of environmental noise.

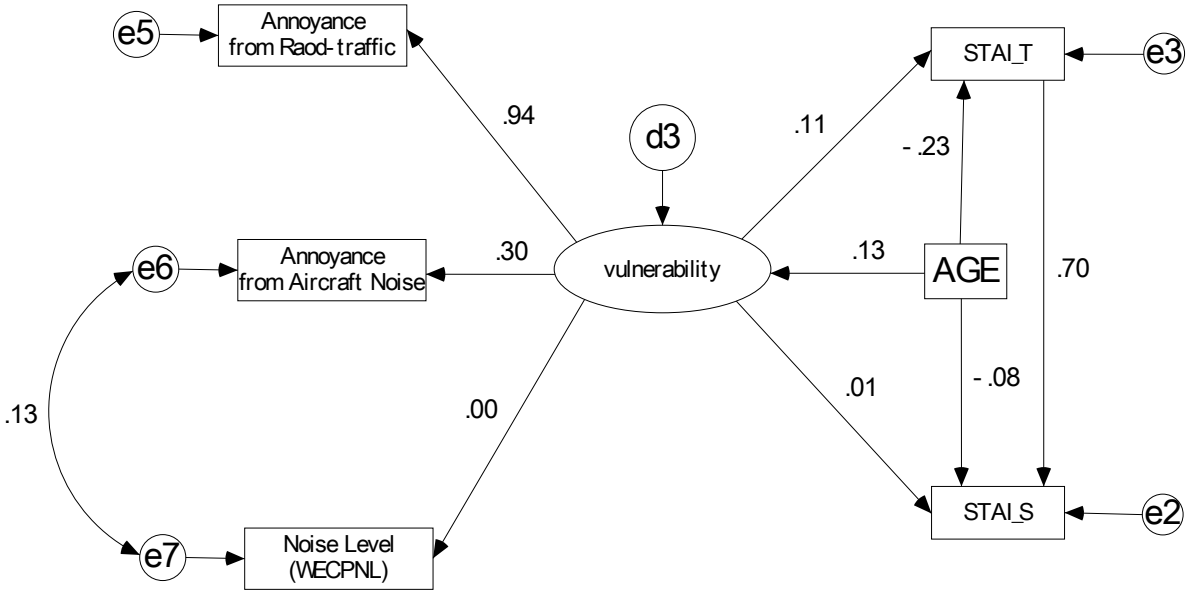


Figure 5: Structural equation modeling for annoyance from transportation noise and anxiety. The model was built with covariance analysis. All the annoyance was evaluated with a Japanese verbal scale of ICBEN model. STAI_T and STAI_S mean the trait- and state- anxiety score. The vulnerability on the center of figure above is an assumed latent variable. Figures attached on arrows are partial correlation or regression coefficients. Indicators for the fitness of this model are as follows:

chi square= 18.306, df = 5, p = 0.003, GFI=0.993, AGIF=0.972.

CONCLUSIONS

In the environment with noise of a middle range level, the noise annoyance and the stress measured with an anxiety scale are dominated by some inner personal factor, such as vulnerability, noise sensitivity or something. Environmental noise seems to explicit the latency just like as opening the boxes.

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