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Community Annoyance from Civil Aircraft Noise in Korea

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Abstract Studies of community annoyance caused by civil aircraft noise exposure were carried out in fourteen areas near Gimpo and Gimhae international airports, Korea, to accumulate social survey data in Korea and to assess the relationship between aircraft noise level and degree of annoyance. Aircraft noise levels were measured automatically by airport noise monitoring system, B&K type 3597. A social survey was carried out people living within 100 meters of noise measurement points, as a rule. Questionnaires were only aggregated face-to-face interviews using various questions which concerned with demographic, degree of noise annoyance, interference with daily activities and health-related symptoms. The questions of noise annoyance were answered on an 11-point numerical scale. The respondents, from 18 to 70 years of age, were randomly selected and completed the questionnaire themselves. The total number of respondents for the questionnaires was 554.

1. INTRODUCTION

In contrast to many other environmental problems, environmental noise pollution (mainly due to transportation noise) continues to grow and has become a serious problem in many countries. The environmental noise problem is difficult to regulate because it involves direct, as well as cumulative, adverse effects of noise on health. According to the International Programme on Chemical Safety (WHO 1994), an adverse effect of noise is defined as “a change in the morphology and physiology of an organism that results in impairment of functional capacity, or an impairment of capacity to compensate for additional stress, or increases the susceptibility of an organism to the harmful effects of other environmental influences” [1]. This definition includes any temporary or long-term lowering of the physical, psychological or social functioning of humans or human organs [1, 2]. Thus, noise effects include various impacts on mental and physical health and interference with daily activities of humans [3-5].
The available environmental health indicators of the adverse effects of noise on health in accordance with ‘Guidelines for community noise’ of the World Health Organization [2] are

as follow:

Annoyance
Speech intelligibility and communication interference
Disturbance of information extraction
Sleep disturbance
Hearing impairment

This paper, however, only concerns annoyance due to environmental noise. Annoyance is a core concept in the area of environmental effects, but its meaning varies considerably among experts [6]. Generally, the concept is associated with disturbance, complain, dissatisfaction, bother, harassment, nuisance, vexation, discomfort, hate and uneasiness because annoyance is extremely related to psychological stress mechanisms.

Annoyance reactions are sensitive not only to acoustical characteristics (source, exposure), but also to many non-acoustical factors of social, psychological or economic nature [7]. There are considerable differences in individual reactions to the same noise. Therefore, methods for evaluating these effects have been extensively studied. And several studies have yielded results suggesting what extent responses may differ by transportation noise sources. Although many social surveys on the effects of community noise have been performed throughout the world, they have been mainly carried out restrict areas, a developed countries, such as Europe and Northern America. The same type of noise, such as that found in residential areas around airports, produce different annoyance responses in different countries. The annoyance response to noise is affected by several factors, including the noise exposure level, the number of events, the time of day, climates and culture [7, 8].

Therefore, the objective of this paper is to accumulate the social survey data in Korea and to assess the relationship between aircraft noise level and degree of annoyance.

2. FIELD SURVEY

The field survey consisted of physical measurements, interviews and analysis.

2.1 Noise measurement

The investigation was performed in fourteen areas around two international airports in Korea (Gimpo and Gimhae airports). These sites were almost under the paths of aircraft for landing and taking off and were chosen to satisfy the requirements of a flat site, free of obstacles.

Noise measurements were carried out using not only airport noise monitoring systems, but portable precision sound level meters at fourteen points. The aircraft noise levels of eleven points were measured automatically by airport noise monitoring system, B&K type 3597. These equipments are managed by ‘Ministry of Environment’. The equipment was held on to a pole on the rooftop to avoid obstacles between the aircraft noise and the receiver. And then, the measurements of three points were carried out by portable precision sound level meter, B&K type 2238. The equipment was held on a tripod on the rooftop also. The microphone was positioned at a height of 1.5m above the ground, and at least 1m from any other reflecting surface.

It is necessary to carry out extensive measurements, in order to calculate the aircraft noise levels. So, the measurements of airport noise monitoring system were made each day for 24h: during May to June periods in 2004. The reliable records of measurements of the aircraft noise exposure levels were that conducted by the ‘Ministry of Environment’ in Korea.

To analyze the aircraft noise level and community response, *WECPNL* was used physical descriptors of the noise. Because *WECPNL* is the rating scale for evaluating the aircraft noise currently being used in Korea.
In Korea, *WECPNL* was modified from the ICAO *WECPNL* to simplify the measuring and evaluating the aircraft noise. It is defined as follows.

$$WECPNL = \overline{L}_A + 10\log\left(N_2 + 3N_3 + 10(N_1 + N_4)\right) - 27 \quad (1)$$

Where, $\overline{L}_A$ denotes the energy mean of all maximum aircraft noise level during a day. N_2 is the number of events during the day time from 07:00 to 19:00 and N_3 is the number of events during the night time from 19:00 to 22:00. N_1 and N_4 is the number of events during midnight from 00:00 to 07:00 and late night time from 22:00 to 24:00, respectively.
Figure 1 indicates the distribution of aircraft noise levels in *WECPNL*, during January to September in 2004. The box plot in figure 1 show the median value (horizontal line), the interquartile range (box) and the largest and smallest observation(whiskers) not being an outlier. Outliers are defined as lying 1.5 box lengths from the edge of the box. However, there were no outliers in this plot. This box is effective way to represent a data distribution, especially difference of data.

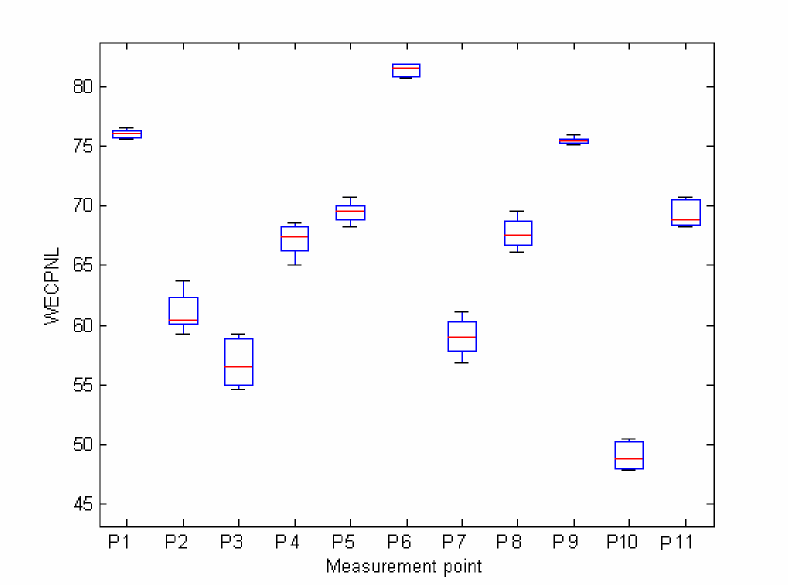

Figure1 : Box plot of distribution of aircraft noise levels in WECPNL

2.2 Social survey

The subjective response to aircraft noise was measured by means of a social survey using questionnaire [9]. The survey was performed in order to investigate the individual's attitude and opinion to different aspects of environmental noise, and it was carried out to residents very close to the location (within about 100 meters) where the noise level measurements were performed. Therefore, it can be assumed that all of them are exposed to the same noise levels. The questionnaire contained demographic questions, degree of noise annoyance, interference with daily activities, psychological and physiological health-related symptoms and reaction against aircraft noise. The questions of noise annoyance were answered on an 11-point (0 to 10) numerical scale. The recommendation for the 11-point numerical scale is based on the

assumption that experiences with decimal-based currency and other based-10 systems make respondents more cognitively familiar with 0 to 10 scaling than with shorter 7 or 9-point numeric scales [10]. The respondent was asked to grade the annoyance experienced. The results were expressed as the percentage of persons in each area who reported that they were “not annoyed” or “extremely annoyed” by aircraft noise, and the percentage of highly annoyed (*%HA*) is calculated for a cutoff at 72 over on the scale from 0 to 100.
To avoid any possibility of bias, the survey was not introduced to the interviewed people in advance, and to increase the reliability of survey, questionnaires were distributed by hand and only aggregated face-to-face interviews. The respondents completed the questionnaire themselves. The total number of respondents for analyses of exposure-effect relationship between aircraft noise level and degree of annoyance were 554.

3. RESULT AND ANALYSIS

About 33% of the respondents were male and 67% were female. The ages of the respondents exhibit a wide range: younger than 20 years (6%), 20–40 (37%), 40–60 (38%) and older than 60 years (19%). Most of respondents were female. And then most respondents (over 80%) got married. These results were owing to the characteristic of a culture pattern in Korea that most female get to be a housewife after they get married.
Regarding community response to civil aircraft noise, about 51% of the interviewed people declared to be “highly annoyed”, 24% “rather annoyed”, 10% “little annoyed” and 15% “not annoyed at all”.
Attitudes to civil aircraft noise were elicited by means of an 11-point numerical scale. When defined as parts of an annoyance scale the term ‘‘highly annoyed’’ is defined as the upper 28% of an annoyance scale and ‘‘annoyed’’ as the upper 50% etc.
The main purpose of the analysis presented in this paper is to provide relationships between civil aircraft noise exposure and the percentage of respondents who were ‘highly annoyed’. ‘Highly annoyed’ variable of annoyance responses is measured as binary data. When the response variable is binary, or binomial proportion, the logistic regression analysis is more appropriate model to predict expected responses. The nature of responses is bounded between zero and one. The logistic model can be expressed as follows.

$$E(Y_i / X_i) = \frac{e^{(\beta_0 + \beta_1 X_i)}}{1 + e^{(\beta_0 + \beta_1 X_i)}} \qquad (2)$$

And besides, because of the binary nature of the response, the equal variance assumption is not valid nor is the assumption that responses vary about the mean according to a normal distribution. Therefore, in order to dispose the problems and estimate the parameters of a logistic model, Maximum Likelihood Estimation (MLE) was used to analyze the relationship between the noise levels and annoyance responses in this study [11, 12].
To assess the effects on health of noise on population, the percentage of persons annoyed (*%A*) or highly annoyed (*%HA*) are recommended indicators of noise annoyance and the day-night average sound level (L_{dn}) is selected as the uniform metric for the description of noise in many countries, such as the European Union, North America and Australia [13, 14, 15].
First of all, the investigation of noise metric was carried out before searching for the relationship between the aircraft noise level and community response. Because what kind of noise metrics such as L_{dn} and *WECPNL* that is used as the rating scale for evaluation the

aircraft noise in Korea are more reasonable for studying the health effects of aircraft noise in this study.

Figure 2 and figure 3 show the *%HA* with respect to *WECPNL* and L_{dn} that is physical descriptors of noise in field survey areas. Figure 2 shows the rising tendency of *%HA* according to *WECPNL*, while figure 3 does not represent upward tendency of *%HA* as regards L_{dn}. The reason of different results causes the difference of calculation method between the *WECPNL* and L_{dn}. *WECPNL* is calculated the energy mean of maximum noise level when an aircraft pass by, while L_{dn} is computed the base on the Equivalent Sound Level (L_{eq}), with a penalty 10dB for night-time noise events.

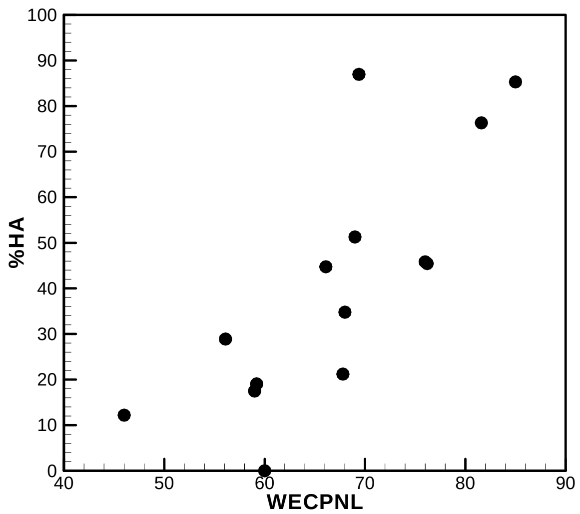

Figure 2 : %HA with respect ot WECPNL

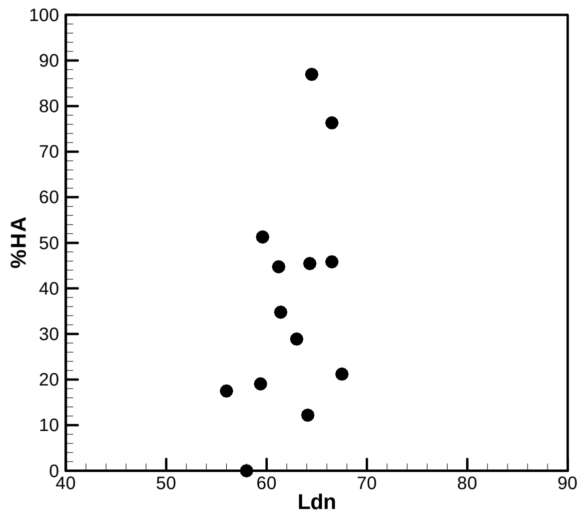

Figure 3 : %HA with respect ot Ldn

Table 1 shows the comparison of measurement data in some field survey area. As shown in this table, the values of *WECPNL* are various but L_{dn} values are almost similar despite various *WECPNL* of different areas. There is difference in *WECPNL* about 8 levels between the point 4 and the point 7, while there is no difference even between the two areas. Because the point 4 is a rural area with rice fields but the point 7 is almost urban area nearby Seoul, the background noise of point 7 is larger than that of point 4. Therefore, even though *WECPNL* owing to the aircraft noise is low, L_{dn} is somewhat high due to the loud background noise in the point 7.

Table 1 : Comparison of measurement data in some field survey area

Measurement point	*WECPNL*	L_{dn}
Point 2	60	58
Point 4	67.4	59.3
Point 5	71.4	61.8
Point 7	59.2	59.4

As in the case of L_{eq}, there is no stipulation of a minimum noise sampling threshold in L_{dn}. Therefore, L_{dn} depends on the influence of background noise and the number of flight. And then, some recent studies have indicated that the use of L_{dn} alone may not be technically sufficient in many situations. Public perception is that an averaging metric, such as L_{dn}, does not correlate well with their response to the short duration of the intruding aircraft noise [16, 17]. *WECPNL*, however, is robust and reasonable metric for applying to the intruding aircraft noise. Because *WECPNL* was only considered not the average acoustical energy above over a 24 hour time period but the energy mean of Maximum Noise Level (L_{max}) when an aircraft pass by, the metric is independent the influence of background noise. In other words, *WECPNL* is computed the base on Maximum Noise Level of individual aircraft events when the over-flight happened. Therefore, physical descriptors of the noise have to be carefully considered for applying to the aircraft noise which has characteristics not fluctuation noise but intermittent noise in the case of not many numbers of flight.

In this study, the physical descriptor of the noise, *WECPNL* was used to assess the effects on health of aircraft noise in population in terms of does-effect relationships between aircraft noise level and degree of annoyance.

Figure 4 shows the percentage of respondents who felt 'highly annoyed' with respect to *WECPNL* for aircraft noise. Round spots are each field survey data showing *%HA* as a function of *WECPNL*. The level of aircraft noise exposure ranges from 46 to 85. The solid line is *%HA* prediction curve that is determined by logistic fit procedure together with the field survey data points. As shown in figure 4, it is found that with increase in the *WECPNL* the percentage of respondents who felt highly annoyed was also increase. And, there is a good relationship between aircraft noise level in *WECPNL* and the percentage of respondents feeling 'highly annoyed'.

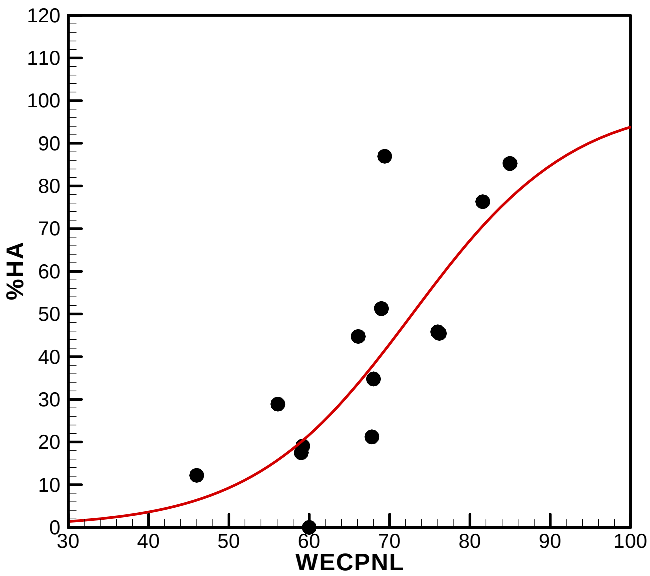

Figure 4 : Prediction curve of civil aircraft noise

4. CONCLUSIONS

In recent years, the percentage of respondents who felt 'highly annoyed' prediction has become a critical component of environmental impact analyses for making environmental decisions regarding transportation noise. The World Health Organization (WHO) has recommended annoyance as one of environmental health indicators to support of environmental noise policy-making and decision activities in many countries. However, WHO doesn't recommend international consensus on how to predict annoyance from transportation noise sources. Therefore, study of community annoyance caused by civil aircraft noise exposure was carried out to accumulate social survey data in Korea and to assess the relationship between aircraft noise level and degree of annoyance. Aircraft noise measurements were carried out fourteen areas near Gimpo and Gimhae international airports, Korea. A social survey was carried out people living within 100 meters of noise measurement points, as a rule. The total number of respondents for the questionnaires was 554. There was a good relationship between aircraft noise level in *WECPNL* and the percentage of respondents feeling highly annoyed. By increasing aircraft noise levels, the percentage of respondents who felt highly annoyed was increased also. It is recommended that the following relationship can be used for environmental noise policy-making purposes in Korea.

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