Social survey on community response to aircraft noise in Ho Chi Minh City

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A social survey on community response to aircraft noise was carried out around Tan Son Nhat Airport in Ho Chi Minh City in August and September 2008; this international airport is Vietnam's largest, and had around 200 take-offs and landings. In total, 1562 respondents participated in the social survey; 880 respondents living in areas apart from main roads were interviewed with a questionnaire on aircraft noise, and 682 respondents living along a main road were interviewed with a questionnaire on the combined noise of aircraft and road traffic. L_{den} (Day-evening-night average sound level) values ranged from 53 to 71 dB for aircraft noise and 73 to 83 dB for combined noise. Dose-response curves for aircraft noise in Ho Chi Minh City were drawn and fitted to curves generated from European Union data. The energy difference model estimated the total annoyance (R^2 = 0.49) better than the energy summation, independent effects, response summation, summation and inhibition, and annoyance equivalents models (R^2 = 0.25–0.48); these results are consistent with Taylor's study. Although the dominant source model—which considers the total annoyance to be predicted by the dominant source annoyance—is not directly comparable with the former models based on physical parameters, its R^2 was 0.82, suggesting the dominant source model's usefulness from a practical point of view.

Key words: Aircraft noise, noise model

1. INTRODUCTION

The rapid emergence of Vietnam's economy has recently increased the transportation needs which are causing the booming of traffic vehicle flows throughout the country especially in urban areas. This also resulted to one type of environmental pollution called "noise pollution". As the same trend, noise pollution has become a common concern of many countries around the world. Global noise policies has been discussed based on huge data sets from European and North American developed countries, but very few data from other continents with different cultures and quality of life [1,2]. Vietnam, like many other Asian countries facing serious noise problems, needs to accumulate a reliable dataset on the relationship between noise and community annoyance in order to establish effective noise regulations to solve this harmful pollution.

A relationship between road traffic noise exposure and Vietnamese annoyance response was initially assessed based on datasets collected from the surveys which were carried out in Vietnam's two largest cities, Hanoi and Ho Chi Minh City, in 2005 and 2007, respectively [3,4]. Along with the rapid development of road traffic, Vietnam's transportation network is now in a phase of strong and rapid growth of the civil aviation market, which is expected to carry 84 million passengers per year by 2020 [5]. The existence of many residential areas in the vicinity of almost all airports has made aircraft emerge as a main noise source together with road traffic, causing adverse effects on the quality of Vietnamese life. The present study on aircraft noise annoyance in Vietnam will provide a database to establish an aircraft noise policy for Vietnam. Moreover, due to characteristics of the transportation network and inhabitation in Vietnam, this can also serve as an additional case study on the combined effect of noise exposure to aircraft and road traffic [6-10].

2. METHODS

2.1 Social survey

A social survey on community response to aircraft noise was conducted at ten residential areas around Tan Son Nhat Airport in Ho Chi Minh City in August and September 2008. Eight sites were chosen under landing and take-off paths for aircraft; two other sites lay to the north and south of the runway. Since the airport is located inside a crowded residential area of

Ho Chi Minh City with busy commercial streets, aircraft noise annoyance was investigated both as a single source and as a combined source with road traffic. In total, 1562 respondents participated in the survey.

Two kinds of questionnaires were used in this study. At the chosen sites, respondents living in areas apart from main roads were interviewed with a questionnaire on aircraft noise, and those living along a main road were interviewed with a questionnaire on combined noise (as shown in Photo 1). Both questionnaires contained inquiries on housing, neighborhood environment, noise annoyance, interferences of daily activities, sensitivity, attitude towards transportation, and socio-demographic data.

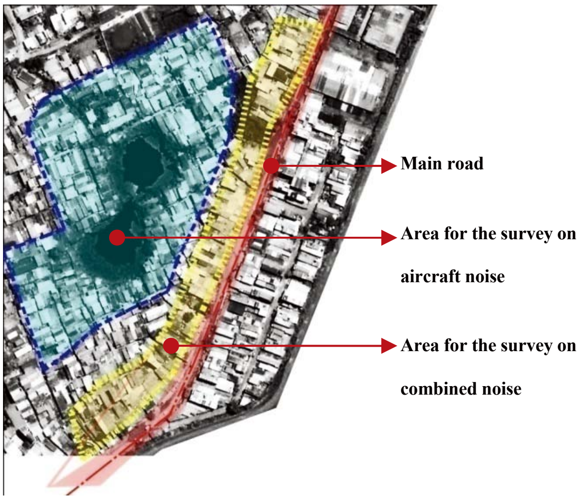

Photo 1: Example of choosing areas for the survey on aircraft noise and combined noises (site 6)

Two scales—a 5-point verbal and 11-point numeric—constructed according to the ICBEN (International Commission on Biological Effects of Noise) method were used to evaluate respondents' annoyance caused by noise [11]. In the questionnaires on aircraft noise, the verbal annoyance question was phrased: *"Thinking about the last 12 months or so, when you are here at home, how much does noise from aircraft bother, disturb, or annoy you?"* The numeric annoyance question was phrased: *"Thinking about the last 12 months or so, what number from 0 to 10 best shows how much you are bothered, disturbed, or annoyed by aircraft noise?"* In the questionnaire on combined noise, similar questions were used to evaluate annoyance caused not only by aircraft noise but also three kinds of noise sources: aircraft, road traffic, and combined noises.

The survey was performed with face-to-face interviews. All interviews were carried out during daytime at the ten sites both on weekends and weekdays. Fathers, mothers, and others were selected in order. Each area needed to have at least 100 houses so that the number of responses would be enough to draw dose-response relationships. The outline of the survey was shown in Table 1.

Table 1: Outline of the social survey in Ho Chi Minh City 2008

Site number	Social survey date		Sample size		Response rate	
			Aircraft	Combined	Aircraft	Combined
Site 1	23,24-Aug	weekend	85	90	85%	90%
Site 2	23,24-Aug	weekend	86	66	86%	66%
Site 3	27,28-Aug	weekday	90	88	90%	88%
Site 4	27,28-Aug	weekday	90	89	90%	89%
Site 5	6,7-Sep	weekend	90	90	90%	90%
Site 6	6,7-Sep	weekend	83	85	83%	85%
Site 7	9,10-Sep	weekday	90	87	90%	87%
Site 8	9,10-Sep	weekday	88	87	88%	87%
Site 9	13-Sep	Saturday	89		89%	
Site 10	13-Sep	Saturday	89		89%	
Total/ Average			880	682	88%	85%

2.2 Noise measurement

Aircraft noise measurements that took place over one week were performed on the rooftops of the highest houses chosen at the ten sites to avoid obstacles between aircraft and the microphones. Microphones covered with omni-weather wind screens were positioned at a height 1.5 m above the roof floor and at least 1 m away from any other reflecting surface.

Aircraft noise exposure was measured with a sampling period of 1 s for a week. The level fluctuations of overall noise exposure at all sites were drawn on charts to identify aircraft noise events. L_{AE} values for each aircraft noise event were calculated from the identified aircraft noise event. Indices such as $L_{Aeq,day}$, $L_{Aeq,evening}$, $L_{Aeq,night}$, and $L_{Aeq,24h}$ were calculated using the L_{AE} of each aircraft noise event. Flight numbers and conditions were obtained from the Airport Office.

Combined noise was measured at eight sites including 24–hour noise measurements were performed at reference points, 1.2 m high and 2.5–5 m away from road shoulders. Short-term 3-min noise measurements were also carried out simultaneously at reference points and several other points. Traffic volume was counted by reproducing video recordings.

3. RESULTS

3.1 Dose-response relationships

Patterned after the European Union (EU) position paper [12], in which the cut-off point for annoyed was defined by the top 50% of annoyance scale, while highly annoyed was defined by the top 28% of annoyance scale, this study defined the top 3 categories of the 11-point numeric scale (top 27%) as highly annoyed. The logistic regression function was applied to establish the dose-response curves for noise annoyance in Ho Chi Minh City and then fitted onto the EU data's curves for aircraft noise annoyance.

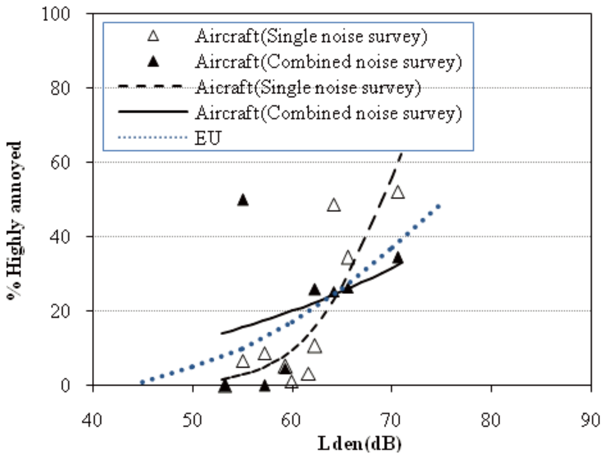

Figure 1: Relationship between L_{den} and percent highly annoyed for aircraft noise in single and combined noise surveys.

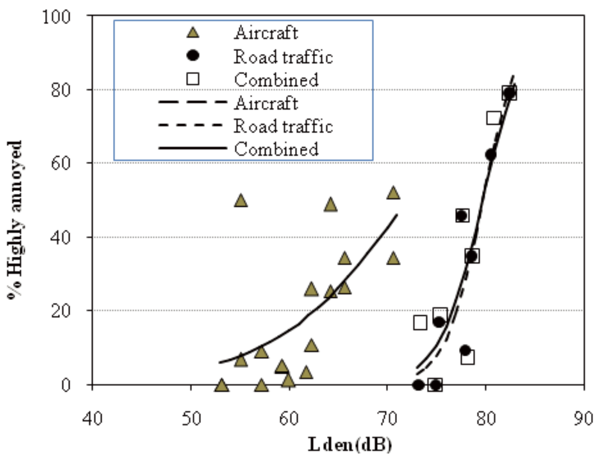

Figure 2: Relationship between L_{den} and percent highly annoyed for aircraft, road traffic and combined noises

As mentioned above, respondents' annoyance caused by aircraft noise was interviewed in both the survey on aircraft noise and the survey on combined noise. To compare the annoyance between the respondents living in areas exposed to aircraft noise as a single source and those exposed to combined noise of aircraft and road traffic, the dose-response curve for aircraft noise annoyance in both the single source and combined source surveys were drawn (Figure 1). As shown in Figure 1, the dose-response curve for aircraft noise annoyance in both the single source and combined source surveys fitted well onto the EU data curve. However, the steepness of the curves is different; the curve for the aircraft noise survey is the steepest, followed by the EU curve, and then the combined survey. When the sound level is higher than 63 dB, the residents exposed to the combined noise of aircraft and road traffic were less annoyed than those exposed only to aircraft noise. This can be explained by the masking effect of road traffic on aircraft noise.

In Figure 2, the dose-response curves for noise annoyance were drawn for three kinds of noise sources investigated in the HCM 2008 survey: aircraft, road traffic, and a combination of the two. The curve for combined noise has the same trend as that for road traffic. The aircraft noise exposure level (L_{den} = 53–71dB) is much lower than that for road traffic and combined noise (L_{den} = 73–83 dB). The level difference between the two curves in Figure 2 ranges from 10 to 20 dB at the same percent highly annoyed.

3.2 Combined noise models

$L_{Aeq,24h}$ and mean annoyance scores for aircraft, road traffic, and combined sources in the survey around Tan Son Nhat Airport are summarized in Table 2.

Table 2: Noise exposure and annoyance data

	Site number	1	2	3	4	5	6	7	8
LAeq,24h	Aircraft	54	49	49	52	66	59	60	57
	Road	71	77	69	71	75	74	74	72
	Combined	71	77	69	71	76	75	74	72
Annoyance	Aircraft	3	1	8	3	7	5	6	6
	Road	4	9	4	4	8	7	4	7
	Total	4	9	6	4	8	6	5	7
	N	59	59	57	54	88	87	84	85

Aircraft noise exposure $L_{Aeq,24h(AC)}$ ranged from 49.4 to 65.8 dB while road traffic noise exposure $L_{Aeq,24h(RT)}$ ranged from 69.3 to 76.9 dB at all sites of the survey in Ho Chi Minh City. In Taylor's study, the noise level represented in Toronto data is from 55.6 dB to 71.1 dB for $L_{Aeq,24h(AC)}$ and from 52.2 dB to 69.9 dB for $L_{Aeq,24h(RT)}$ [8]. This indicates the different combinations of aircraft and road traffic noise between two studies. The annoyance at each site was calculated by using the unweighted mean of the annoyance score.

Table 3: Regression equations for mixed source models

Models	Equation	R^2
Energy summation	$A_T = -29.973 + 0.494\ L_T$	0.474
Independent effects	$A_T = -30.412 + 0.526\ L_{RT} - 0.034\ L_{AC}$	0.474
Energy difference	$A_T = -30.479 + 0.490\ L_T + 0.045\ L_{DIFF}$	0.490
Response summation	$A_T = -28{,}527 + 0.472*(L_T + 10.25 * 10^{(L_{AC}-L_T)/10})$	0.480
Summation + inhibition	$A_T = -10.350 + 0.211\ L_{T(CORR)}$ (D=14)	0.185
	$A_T = -13.264 + 0.251\ L_{T(CORR)}$ (D=12)	0.249
Equivalents annoyance	$A_T = -40.749 + 0.621L$	0.440
Dominant source	$A_T = -0.519 + 0.999\ A_D$	0.824

As shown in Table 3, the coefficient of determination R^2 indicates the percent that the model accounts for variability in the total noise annoyance. The result show that the energy difference model estimated the total annoyance (R^2 = 0.49) better than energy summation, independent effects, response summation, summation and inhibition, and annoyance equivalents models (R^2 = 0.25–0.48). This is consistent to Taylor's study at Toronto International Airport. However, the dominant source model—which implies that the overall annoyance is always equal to the highest single source annoyance. —is the one having the highest value of R^2 (R^2=0.82), suggesting it is the most useful model in rating the noise annoyance around Tan Son Nhat Airport.

Miedema criticized the dominant source model in that it does not describe the empirical data correctly since the total annoyance increases if the annoyance level of non-dominant source approaches that of the dominant source [13]. This above result can be explained by the case of the Ho Chi Minh survey, where the difference in noise level between two sources is rather large (as shown in Figure 2).

4. CONCLUSIONS

Dose-response relationships for aircraft noise annoyance in both the single noise and combined noise surveys were drawn and fitted onto a curve drawn from EU data.

In addition, dose-response curves for noise annoyance were drawn for three kinds of noise sources investigated in the HCM 2008 survey: aircraft, road traffic, and a combination of the two. The curves for road traffic and combined noise are at almost the same position. These curves indicate the representative relationships for a situation of big cities in Vietnam, where road traffic shows to be the main noise source.

Seven models were compared in term of their power to predict the total annoyance due to the combined noise of aircraft and road traffic. The regression analysis results confirmed the superiority of the dominant source model over other models in predicting annoyance caused by a combined noise. However, the results obtained here may be only effective for the noise environment around Tan Son Nhat Airport, where the road traffic noise level is considerably higher than the aircraft noise level. Further data and analysis should be accumulated for the combination of two noise sources in Vietnam.

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