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Follow-up examination of the community response to aircraft noise after 11 years around Tan Son Nhat Airport

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ABSTRACT

A representative exposure–response relationship for aircraft noise annoyance in Vietnam was established partly based on data obtained from a social survey on community response to aircraft noise were carried out around Tan Son Nhat International Airport (TIA), Vietnam's largest airport, in 2008. The question is whether the response to noise change thought out the time and if the established relationship is suitable for the present consideration for future aircraft noise regulations. This study provided a comparison between the previous survey in 2008 and the recent investigation on noise impact conducted at the same residential areas near TIA in 2019. The average flight number increased from 200 in 2008 to more than 720 in 2019. Accordingly, the day-evening-night noise level (L_{den}) ranged from 53 to 71 dB and from 63 to 81 in 2008 and 2019, respectively. The percentage of highly annoyed respondents in an area of above 70 dB (L_{den}) was 52% in the 2008 survey, while this number only 12 percent in the 2019 survey. The residents living in the noisier environment seem to be more tolerant of noise.

INTRODUCTION

European and American studies report that the reaction of people to aircraft noise increases in severity every year [1]. World Health Organization (WHO) conducted a systematic review [2–5] of the effects of environmental noise and announced their results in the Environmental Noise Guidelines for the European Region (2018) [6]. These guidelines strongly recommended reducing aircraft noise levels to 45 dB L_{den} (day-evening-night-weighted sound pressure level) and 40 dB L_{night} (night-time equivalent continuous sound pressure level) to protect the health of residents around airports. Further, although the recommended values were derived using data obtained globally, few data points were obtained from Asia (in particular, from Asian developing countries). Further studies in developing countries are thus required to verify the applicability of the recommendation.

The Tân Sơn Nhất (TSN) international airport—located inside a very dense residential area of Ho Chi Minh City, the most active metropolitan area in Vietnam—is the largest airport in Vietnam, with over 250,000 movements, and it served approximately 40 million passengers in 2018 [7].

This paper compares the community responses from two surveys conducted in 2008 and 2019 around the TSN. The 2019 study acts as a follow-up examination of the community's response to noise after 11 years by surveying the same areas as the 2008 study [8]. The number of flights at present is 3.3 times greater than that in 2008. This research project aims to answer these questions: (1) Is there a secular change in the community reaction owing to the increase/decrease in exposure to aircraft noise? (2) Are the WHO guidelines applicable to developing Asian countries?

DATA COLLECTION

Survey Sites

In Survey 2008, ten residential areas were selected around TSN airport (Sites A1–A10), eight sites under the landing and takeoff paths of the aircraft and the two others at the north and south of the runway, respectively (see Figure 1). The site selection was intended to reflect aircraft noise exposure covering locations at various distances from and in directions relative to the airport. In the follow-up survey in 2019, a total of 10 sites (Sites B1–B10) near the sites of the 2008 survey were investigated.

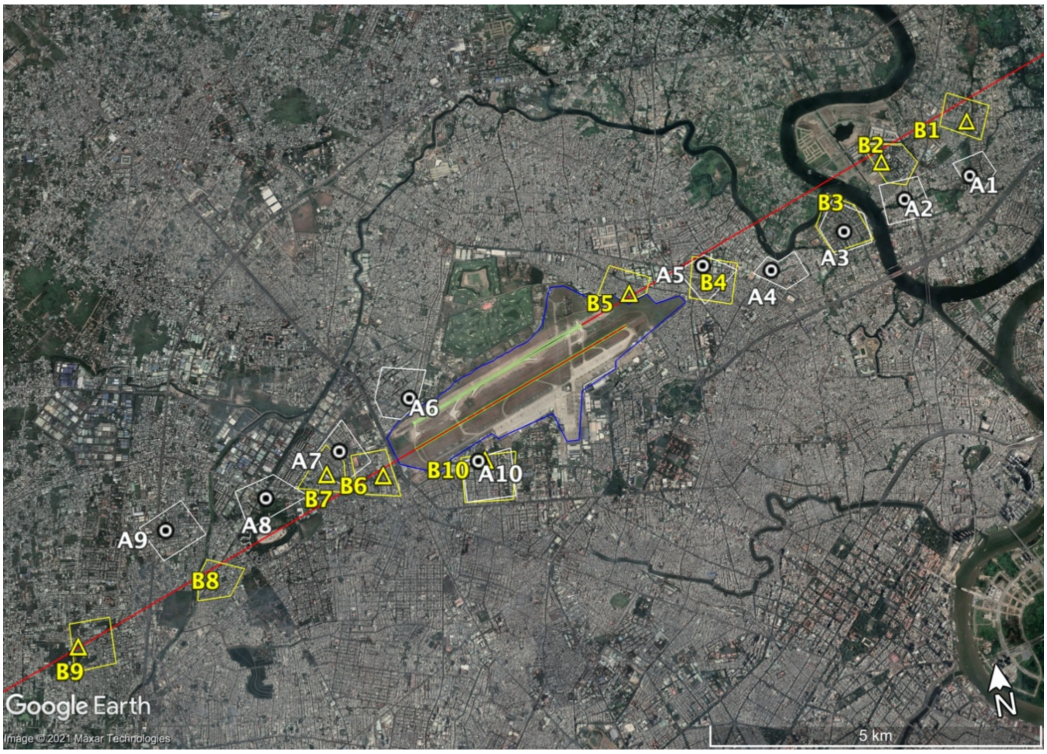


Figure 1: Map of surveyed sites in 2008 (A1–A10) and 2019 (B1–B10)

Socio-Acoustic and Health Surveys

Community responses to aircraft noise were investigated around the TSN airport between August and September 2008 and August 2019. The surveys were conducted via face-to-face interviews during the daytime on weekends. The interviewers visited and collected responses from all of the residences in the selected study area. Because the response rate was quite high, nonrespondent analysis was not performed. In both surveys, the composition of the interviewees in each household was adjusted to have the same rate of demographic factors as that in the Vietnam Census. In particular, to ensure a balance between males and females and generations, fathers, mothers, and other adults in the family were selected for the survey.

The design of the questionnaire followed the Technical Specification ISO/TS 15666 [9]. The questionnaire not only focused on noise but also on various components of the living environment. We focused on analyzing and comparing similar data between the two surveys. The primary outcomes of noise impact considered in this study were annoyance and self-reported sleep disturbances. Table 1 lists the questions and scales used to assess them in both surveys.

Annoyance and sleep effects are the most widely used measures of the human response to noise. The standardized annoyance question and the 11-point numeric scale used in this study are as recommended by the International Commission on Biological Effects of Noise (ICBEN) [10]. In both surveys, the aircraft noise-induced annoyance was represented by the percentage of respondents who were highly annoyed (%HA): percentage of respondents who chose 8, 9, or 10 out of the 11-point numeric scale (0–10).

Table 1: Outcome: Annoyance and sleep disturbance questions used in the surveys.

Survey	Annoyance Questions	Sleep Disturbance Questions
2008	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? 11point scale used from 0 (not at all) to 10 (extremely) (HA [a]:8, 9, 10)	How is the status of your daily sleep? Extremely good; Good; Neutral; Bad; Extremely bad. (LSQ [c]: Bad, Extremely bad)
2019	Same	During the past 4 weeks, how would you rate the quality of your sleep overall? 1. Very good; 2. Fairly good; 3. Fairly bad; 4. Very bad.

[a] Highly annoyed. [b] Highly sleep disturbed. [c] Low sleep quality.

To compare the effect on sleep between the two studies, we used data relating to sleep quality measured by two similar-content questions used in the two surveys. Because the evaluation scales are different, we can only compare the trends of the outcomes.

Noise Exposure Data

The predicted values and data required for prediction such as flight route, runway use, flight operation data, and airplane performance could not be obtained in the 2008 survey. Therefore, field measurement values were used to estimate the noise exposure, L_{den} and L_{night}, in this survey, which within the same site was considered equal. In Survey 2019, noise measurement and flight route data collection for the estimation of noise exposures around the airport were conducted simultaneously. To check the accuracy of the noise estimation, the noise was measured for one week (August 4–11) by applying the same method as in the 2008 survey.

Noise exposure obtained from field measurement was used in the analysis for the 2008 survey, with one exposure value per survey site, whereas calculated values were used instead of the measurements in the analysis for the 2019 survey, with the exact values at the residents' addresses. The relationship between the obtained noise exposure and the reaction of the residents was clarified for the data of the 2019 survey, and the change in the reaction of the residents over the 11-year span was examined by comparing it with the exposure–response relationship obtained in 2008.

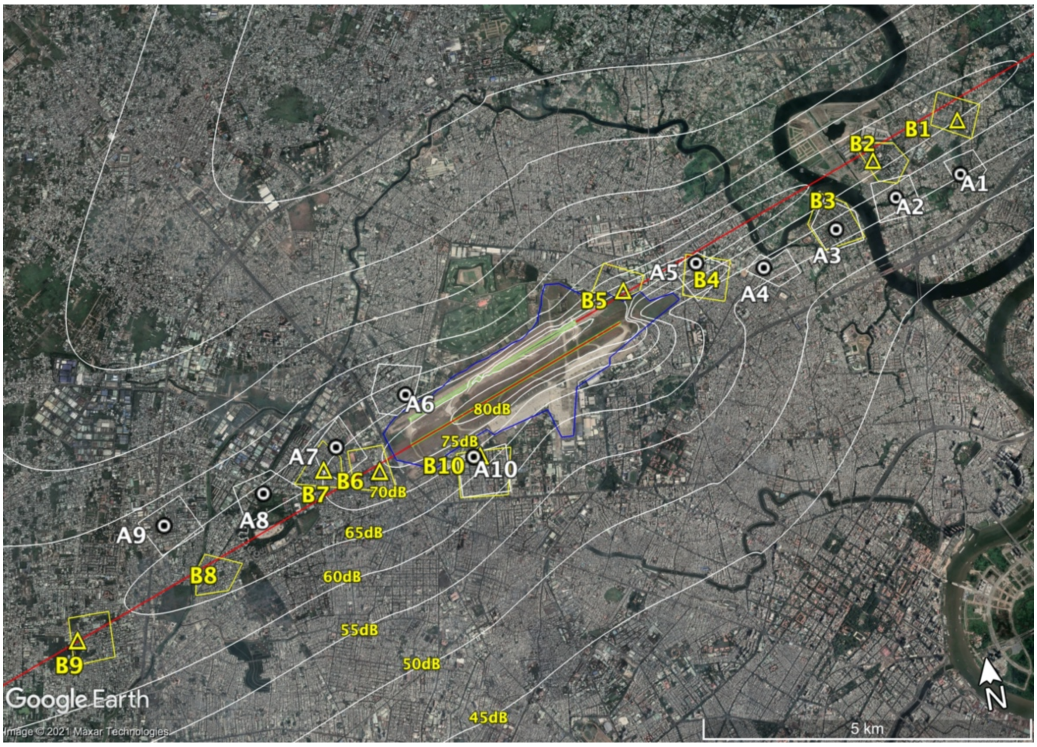


Figure 2: Noise map of 2019

In the maps shown in Figures 1 and 2, the dots represent the installation locations of the sound level meters, while the zoned areas represent the area of the questionnaire surveys. In the 2019 survey, the measurements were not performed at Site B4 because no appropriate house for noise measurement installation was available. Noise measurements at sites B3 and B8 failed because of errors in data storage. Therefore, the dots are not shown for these sites in the map, and no comparison was conducted between estimated and measured values at these sites.

RESULTS

Demographic Data of the Respondents

A total of 880 and 502 responses were obtained in the 2008 and 2019 surveys, respectively. The demographic data of the survey respondents are summarized in Table 2. A higher response rate was achieved in the 2008 survey. In both surveys, the proportion of female respondents was slightly higher. Respondents aged over 60 years accounted for 11% and 18% of the total number of respondents in the 2008 and 2019 surveys, respectively. These obtained proportions are consistent with the characteristics of the young population (less than 60 years) of Vietnam. The proportion of employed respondents in the follow-up survey was higher than that in the 2008 survey.

Increase in Number of Flights and Noise Levels

The number of operated flights and passengers at the TSN airport has increased significantly over the past 11 years. Table 3 summarizes the average number of daily flights operated by the TSN during the two survey periods. The number of night flight events accounted for approximately 18.3% of the total number of flights in 2019, while this number was 13.8% in the 2008 survey. The increase in night-time flights is attributed to the rapid growth of low-cost carriers, which prefer operating at night (22:00–6:00) to save costs; this trend seems to reduce the flight components during the day and evening. The same pattern was observed at Hanoi Noi Bai Airport [8].

Table 2: Demographic data of the respondents in both surveys

Items		**Surveys**		**Vietnamese Census (2019) ***
		2008	2019	
Number of respondents		880	502	
Response rate (%)		88	60	
Sex (%)	Male	47	46	50
	Female	53	54	50
Age (%)	20–50 years	89	82	88
	≥60 years	11	18	12
Occupation (%)	Employment	45	54	74 [a] 55 [b]
	Student, homemaker, retired, unemployed	55	46	26 [a] 45 [b]

(*): General Statistics Office in Vietnam, "Statistical Date" http://www.gso.gov.vn/default_en.aspx?tabid=491 (accessed on 22 February 2021). [a] calculated in >15-year-olds population. [b] calculated in all population.

Table 3: Average number of aircraft noise events

Time Period	**Operation Modes**	**Surveys**	
		2008	**2019**
Day (6:00–18:00)	Arrival	67	214
	Departure	82	244
	Total	149	458
Evening (18:00–22:00)	Arrival	28	73
	Departure	16	64
	Total	44	137
Night (22:00–6:00)	Arrival	17	77
	Departure	14	56
	Total	31	133
All day	Arrival	112	364
	Departure	112	364
	Total	224	728

Table 5 shows the average noise levels obtained during each survey period; the noise levels in the 2008 survey represent measured values, and those in the 2019 survey are the predicted values. L_{den} obtained at Sites A1–A10 ranged from 53–71 dB in 2008, while L_{den} ranged from

63–81 dB at the noise-exposed sites B1–B10 in 2019. These ranges are 45–62 dB in 2008 and 55–74 in 2019 with noise exposure at night. Among the 10 investigated sites, the measurement points at Site A10 of the 2008 survey and B10 of the 2019 survey coincided, and both L_{den} and L_{night} were found to increase by 7 dB.

Table 4: L_{den} [a], L_{night}. [b], and their changes from the 2008 survey to 2019 survey

2008 Survey			2019 Survey		
Site	L_{den} [a]	L_{night} [b]	Site	L_{den} [a]	L_{night} [b]
Site A1	59	52	Site B1	64	57
Site A2	53	45	Site B2	65	58
Site A3	55	48	Site B3	66	58
Site A4	57	49	Site B4	63	55
Site A5	71	62	Site B5	81	74
Site A6	64	56	Site B6	74	66
Site A7	66	58	Site B7	70	62
Site A8	62	55	Site B8	66	58
Site A9	62	54	Site B9	64	56
Site A10	60	53	Site B10	67	60

[a] Day-evening-night-weighted sound pressure level. [b] Night-time equivalent continuous sound pressure level.

The TSN airport has two parallel runways in the east–west direction (07L–25R and 07R–25L). The runway was used quite differently in 2019 than in 2008. In 2008, the airport used the southern runway (07R–25L) located close to the civil airport terminal, while the northern runway (07L–25R) served as a military airbase. In 2019, the military airbase was relocated to another place, and both runways were used for civilian aircrafts to meet the high density of flight flow at the airport. The three sites on the landing side in 2019 (Sites B1–B3) were shifted to the north compared to the corresponding three sites in 2008 (A1–A3) with the same distance to the 25R runway end. The difference in noise levels between these sites ranges between 5–12 dB, which reflects the increase in the flight numbers and the more frequent use of the northern runway. The noise exposure in the 2008 survey included noise released by military aircrafts, while there is only noise from civil flights in the 2019 survey.

Changes in General Annoyance and Sleep Effects

As summarized in Table 5, %HA ranged between 0 and 52% in the 2008 survey (corresponding to a 53–71 dB range of L_{den}). Meanwhile, this range in 2019 is 0–18% (corresponding to a 63–81 dB range of L_{den}). The highest %HA was at Site 5 in the 2008 survey, while in the 2019 survey, it was at Site B6. The %HA was only 3% at the noisiest site in the 2019 survey (Site B5), which is located nearest to the 25R runway end on the landing side and exposed to 81 dB (L_{den}). Despite having to live in a noisier environment than before, the residents around the TSN airport seem more tolerant to the noise.

The percentage of low sleep quality in the 2008 survey ranged between 2% (Site A10, 53 dB L_{night}) to 27% (Site A5, 62 dB L_{night}). This range is 4% (Site B10, 60 dB L_{night}) to 35% (Site B6, 66 dB L_{night}) for the 2019 survey. Comparing the data for Sites A10 and B10, which are two coincident survey areas, the %LSQ was observed to increase from 2% to 4%. However, the %LSQ at Site B5 in the 2019 survey was low, at only 15%, with a high L_{night} of 74 dB. The highest %LSQ of the 2019 survey was 35% at Site B6, an area of 66 dB (L_{night}). This result is consistent with the high %HA obtained at this site. Although residents around the TSN airport seem to be more tolerant of noise than that in the 2008 survey, the trend for reported sleep quality is different. This finding indicates that the effect of noise at TSN airport on the sleep quality of residents requires more attention from airport operators. The correlation coefficient between %HA and %LSQ in the 2008 survey, $r = 0.725$ ($p = 0.0177$), indicates a strong positive linear relationship. The correlation coefficient between %HA and %LSQ in the 2019 survey, $r = 0.289$ ($p = 0.4176$), indicates a weak positive linear relationship.

Table 5: Percentage of highly annoyed (%HA) and percentage of low sleep quality (%LSQ)

2008 Survey				**2019 Survey**			
Site	**%HA [a]**	**%LSQ [b]**	**No. of Responses**	**Site**	**%HA [a]**	**%LSQ [b]**	**No. of Responses**
Site A1	5	7	85	Site B1	0	14	48
Site A2	0	8	86	Site B2	7	12	41
Site A3	7	3	90	Site B3	0	27	31
Site A4	9	8	90	Site B4	2	18	49
Site A5	52	27	90	Site B5	3	15	33
Site A6	49	11	83	Site B6	18	35	49
Site A7	34	12	90	Site B7	13	10	48
Site A8	11	9	88	Site B8	6	12	32
Site A9	3	13	89	Site B9	0	22	45
Site A10	1	2	89	Site B10	2	4	33

[a] Percentage of respondents who were highly annoyed. [b] Percentage of respondents who had low sleep quality.

Table 6 summarizes the percentage and number of highly annoyed respondents in the two surveys at different noise exposure level ranges. The *p*-value derived by the Wald test determines whether L_{den} can be used to predict or correlate with %HA. The *p*-value shows that L_{den} was significantly associated with %HA in the 2008 survey at the <0.0001 level and in the 2019 survey at the <0.01 level. That is, higher noise levels increased the possibility of being highly annoyed in both surveys.

Table 6: Comparison of percentage of highly annoyed (%HA) at different noise level ranges of the 2008 and 2019 surveys

		Noise Level Ranges L_{den} [a] (dB)				**p-Value**
		<60	60–65	65–70	>70	
2008 survey	%HA	5.2	15.5	34.4	52.2	<0.0001
	Response number/N	17/330	53/341	31/90	47/90	
2019 survey	%HA		0.7	6.1	12.2	0.0082
	Response number/N		1/142	12/197	10/82	

[a] Day-evening-night-weighted sound pressure level.

A comparison was drawn using the data on %LSQ at different ranges of L_{night} (Table 7). The *p*-value derived by the Wald test shows that L_{night} was significantly associated with %LSQ in the 2008 survey. This association was not observed in the 2019 survey data ($p = 0.3974$).

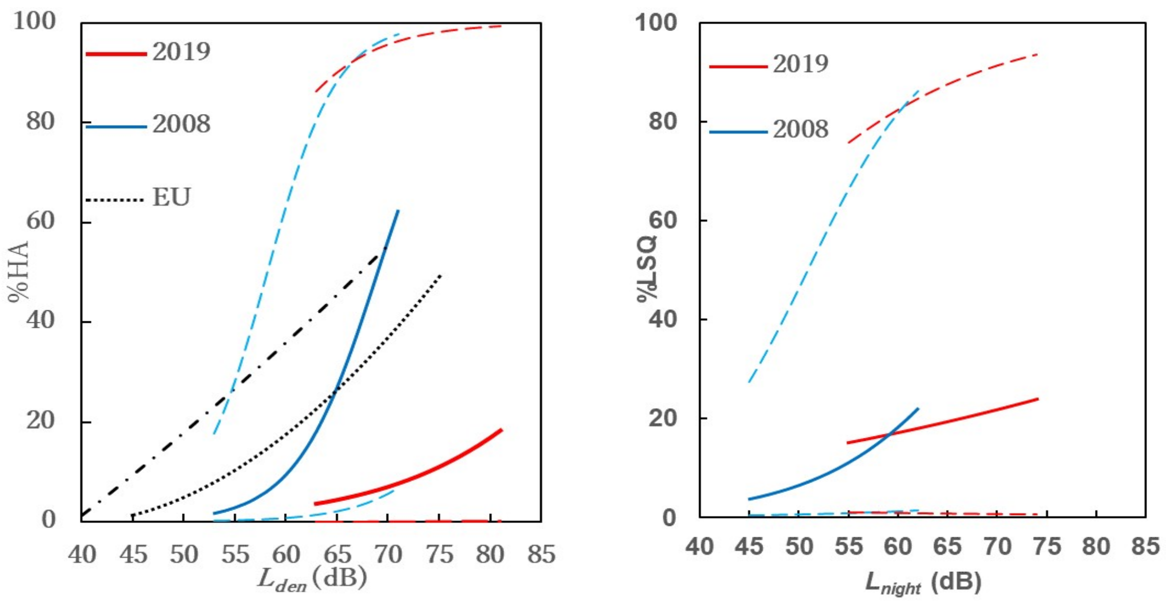
Table 7: Comparison of percentage of low sleep quality (%LSQ) at different noise level ranges of the 2008 and 2019 surveys

		Noise Level Ranges L_{night} [a] (dB)					**p-Value**
		<50	**50–55**	**55–60**	**60–65**	**>65**	
2008 survey	%LSQ	6.5	7.8	11.6	26.7		<0.0001
	Response number	17/260	27/345	20/172	24/90		
2019 survey	%LSQ			15.2	10.4	26.8	0.3974
	Response number			45/297	5/48	22/82	(n.s)

[a] Night-time equivalent continuous sound pressure level.

A logistic regression analysis was used to establish an exposure–response relationship for each study. Figure 3 shows a comparison of (a) L_{den}–%HA and (b) L_{night}–%LSQ relationships for the two studies. The L_{den}–%HA relationship of the 2019 survey was lower than that of the 2008 survey, while the L_{night}–%LSQ relationships of the 2019 survey almost coincided with that of the 2008 survey. However, the 2019 curve is much flatter. The curve for the 2019 study can be considered an extension of the 2008 curve.

Relationships obtained in this study were compared to those established in the Position Paper on European Union (EU) Noise Indicators [11] and the Environmental Noise Guidelines for the European Region by the WHO [6]. The %HA was obtained from the top 27–28% on the evaluation scale. The exposure–response relationship of both surveys was found to be lower than the relationship established in the WHO guidelines. The exposure–response relationship established in 2008 was closer to the relationship established in the EU position paper. The relationship of the 2019 survey was lower than those established in the WHO guidelines, which indicated the tolerance of the residents to aircraft noise around the TSN airport.



(**a**) (**b**)

Figure 3: Comparison of (**a**) L_{den}–%HA and (**b**) L_{night}–%LSQ relationships with 95% confidence interval between the 2008 and 2019 surveys

Influence of Residential and Nonacoustic Factors

Nonacoustic factors influence the reported aircraft noise annoyance and activity disturbance as significantly as the noise exposure level [19–22]. The data on the residential and nonacoustic factors of the respondents investigated in both surveys. Chi-squared tests of independence were performed by comparing these factors for the two surveys. A significant difference was observed in most categories, except housing type, house width, sex, sensitivity to cold, vibration, chemicals, odors, and job components. The negative evaluation of residential areas regarding green, street scenery, view, quietness, work convenience, education convenience, health care convenience, daily life service convenience, and transport convenience—defined by the percent of bad and extremely bad responses—was lower in the 2019 survey. That is, the respondents in the 2019 survey were considerably more satisfied with their living areas than those in the 2008 survey. This change is consistent with the fact that with the positive change in the economy, the living amenities of the residents around the TSN airport improved, including the increased use of air conditioners. This improvement was indicated by a decrease in the percentage of open windows.

Multiple logistic regression models were constructed with only the variables that significantly affected the prevalence of annoyance or LSQ. Tables 8 and 9 show the results of the analysis. Significant associations were found between L_{den} and annoyance (p < 0.0001) and between L_{night} and LSQ (p = 0.0008). The survey factor adjusted by the other nonacoustic factors significantly affected the prevalence of annoyance at the <0.0001 level and the LSQ at the <0.001 level. The variable representing the interaction of noise exposure and survey factor, survey factor * L_{den} (Table 8) and survey factor * L_{night} (Table 9), had a significant effect on annoyance and LSQ, respectively. It is worth noting that the coefficient of the interaction between noise level (L_{den} or L_{night}) and survey factor is negative in both models. It indicated that the effect of survey factor decreased when noise exposure increased, and vice versa.

The evaluation of work convenience and noise sensitivity had a significant effect on the prevalence of annoyance. Age, evaluation of the green environment, and noise sensitivity had significant effects on the prevalence of LSQ. The odds of residents above 60 for LSQ are 2.497 times of that under 60. In other words, general noise annoyance is influenced by work convenience assessments, while sleep quality is influenced by the age and the green surroundings around the house. These results suggest that residents may be less likely to be annoyed if they find their living areas convenient for work. The sleep quality of residents in noisy areas can be improved if they are satisfied with the green surroundings around the house. The coefficient of the survey factor is negative in the model of annoyance but positive in the models of LSQ. With the adjustment of the survey factor, the rate of negative response to the noise around the TSN airport decreased in terms of general annoyance but increased in terms of low sleep quality. The odds that the resident was highly annoyed in the 2019 survey compared to those of the 2008 survey was 0.260. In other words, the odds that a resident was highly annoyed by noise in the 2008 survey was 3.850 times the odds in the 2019 survey. On the contrary, the LSQ model showed that the odds of having bad sleep quality in 2019 were 2.177 times the odds in 2008.

Table 8: Multiple logistic regression for annoyance (HA) (Generalized R^2: 0.2815; AUC: 0.856)

Item	Category	Estimate	Std Error	*p*-Value	Odds Ratio	Lower 95%	Upper 95%
Intercept		−16.509	1.624	<0.0001			
L_{den} [a]		0.224	0.025	<0.0001	1.250 [b]	1.313 [b]	0.800 [b]
Survey factor	2008 survey				1		
	2019 survey	−1.348	0.361	0.0002	0.260	0.128	0.527
L_{den} [a] x Survey factor		−0.187	0.050	0.0002			
Sex	Male				1		
	Female	0.100	0.199	0.6156	1.105	0.748	1.633
Age	≤60 years				1		
	>60 years	0.622	0.304	0.0406	1.864	1.027	3.381
Green	Satisfied				1		
	Dissatisfied	0.330	0.244	0.1753	1.392	0.863	2.244
Work convenience	Satisfied				1		
	Dissatisfied	1.084	0.279	0.0001	2.956	1.710	5.110
Noise sensitivity	Insensitive				1		
	Sensitive	1.527	0.200	<0.0001	4.604	3.109	6.820

[a] Night-time equivalent continuous sound pressure level. [b] Odds ratio in 1 dB change.

Table 9: Multiple logistic regression for low sleep quality (LSQ) (Generalized R^2: 0.1054; AUC: 0.733)

Item	Category	Estimate	Std Error	*p*-Value	Odds Ratio	Lower 95%	Upper 95%
Intercept		−7.963	1.487	<0.0001			
L_{night} [a]		0.090	0.027	0.0008	1.095 [b]	1.154 [b]	0.914 [b]
Survey factor	2008 survey				1		
	2019 survey	0.778	0.227	0.0006	2.177	1.394	3.400
L_{night} [a] x survey factor		−0.098	0.037	0.0078			
Sex	Male				1		
	Female	0.230	0.185	0.2130	1.259	0.876	1.809
Age	≤60 years				1		
	>60 years	0.928	0.232	<0.0001	2.529	1.605	3.987
Green	Satisfied				1		
	Dissatisfied	0.708	0.221	0.0014	2.030	1.316	3.133
Work convenience	Satisfied				1		
	Dissatisfied	0.064	0.344	0.8529	1.066	0.543	2.093
Noise sensitivity	Insensitive				1		
	Sensitive	1.190	0.204	<0.0001	3.288	2.206	4.901

[a] Night-time equivalent continuous sound pressure level. [b] Odds ratio in 1 dB change.

DISCUSSION

Effects of Nonacoustic Factors on Noise Exposure–Response Relationships

Noise sensitivity was found to be a significant factor affecting the prevalence of annoyance and low sleep quality in Ho Chi Minh City. This finding is consistent with that of previous studies, which defined self-reported noise sensitivity as a nonacoustic factor that significantly influences noise exposure–response relationships. Further, dissatisfaction with the living environment in terms of inconvenience to work affects noise annoyance. Thus, satisfaction with convenient access to the workplace reduced the negative response for Ho Chi Minh City.

According to the results of a 2019 survey on the population and housing census of Vietnam [12], the housing and living conditions in Vietnam improved over the last ten years, especially in the urban areas. The number of households that now owned modern living facilities increased compared to those in the 2009 census. Remarkably, the percentage of households in Vietnam equipped with air conditioners increased by 25.5% (2009: 5.9%, 2019: 31.4%). The increased number of air-conditioner-equipped houses is directly related to the decreased window-opening frequency. This change may improve the sound insulation performance of windows, thereby indirectly making the house more insulated to noise and contributing to a reduction in noise annoyance. This moderation effect should be examined further because annoyance also depends on outdoor exposure because people often stay outdoors.

Nonacoustic factors such as noise sensitivity, age, and dissatisfaction with the green environment of living areas were found to influence the sleep quality of residents in Ho Chi Minh City at a higher significance level compared to night-time noise exposure. This result is consistent with a study on more than 259,000 Australians, which found that people living in greener neighborhoods reported a lower risk of short sleep [13]. This result suggests that more green space within the neighborhood environment can help ease the negative sleep effect of the increased noise scenario.

Change in Aircraft Annoyance and Implications for the Environmental Quality Standard for Aircraft Noise

The significant influence of the survey factor in the multiple regression analysis confirmed the difference in the residents' reactions to the noise between the two surveys. The reaction to aircraft noise in 2019 was lower in terms of annoyance but higher in terms of low sleep quality compared to the reaction in the 2008 study. The relationship of annoyance in the 2019 survey was lower than that established in the EU position paper and the WHO guidelines. The findings of this study suggest that the degree of reaction to the increase in aircraft noise differs between annoyance and sleep effects.

The result of decreased annoyance in the 2019 survey compared with that of the 2008 survey in Ho Chi Minh City is opposite to the that observed in recent studies that reported aircraft noise annoyance increased in Europe. Reports by both Babish et al. [14] and Janssen et al. [15] suggest that the EU standard curve for aircraft noise should be modified. This conclusion is not in line with this study's finding that the excess response did not occur with an annoyance reaction but with a sleep effect in the TSN case.

Another reason for the decreased annoyance at a given noise exposure might be that the noise exposure increased strongly around the TSN airport, whereas in Europe, noise exposure remained stable or even decreased over time, which may be changing the expectations of residents. Gjestland and Gelderblom examined the community tolerance level values (CTL) for 32 aircraft noise surveys concerning the yearly number of aircraft movements [16]. Their study found that around low-rate-of-change airports like European airports, the prevalence of highly annoyed residents increases with the number of movements. However, the same tendency cannot be found for high-rate-of-change airports like the TSN airport. At airports experiencing large changes in their operational patterns, the annoyance assessment is most likely dominated by other nonacoustic factors, and the effect of the number of movements seems to be absent or masked. This conclusion does not strongly support, but is not contrary to, our study's findings.

CONCLUSIONS

We analyzed the data of 2008 and 2019 aircraft noise surveys in Ho Chi Minh City and compared changes in noise annoyance and sleep quality based on the results of both surveys. Annoyance was significantly reduced in 2019 compared to that in 2008; however, changes in sleep quality were relatively small. This study demonstrates a contradictory tendency compared to that presented in recent studies, which report that aircraft noise annoyance increases over time. The decline in annoyance in the 2019 survey was found to be related to increased satisfaction with the convenience of accessing the workplace. The other cause is attributed to the increased number of households equipped with air conditioners, which indirectly reduced indoor noise exposure because the residents could close windows more frequently. Satisfaction with the green environment of living areas was found to lower the rate of low sleep quality. The positive air-transport attitudes of the residents were also found to be an important factor that contributed to minimizing aircraft noise annoyance in Ho Chi Minh City. These findings can help policymakers, aviation authorities, and environmental managers to design effective measures for mitigating noise impacts on residents in the vicinity of busy airports.

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