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タンソンニャット空港周辺の航空機騒音の減少前後のアノイアンスと睡眠妨害の構造方程式モデルの比較

Comparing Structural Equation Models Of Noise Annoyance And Insomnia Before And After A Decrease In Aircraft Noise Around Tan Son Nhat Airport

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Abstract: Tan Son Nhat (TSN) was the busiest airport in VietNam before the coronavirus pandemic and had several noise problems. All flights were closed at the end of March 2020 due to the coronavirus pandemic, causing a dramatic change in the acoustic environment around TSN airport. The noise levels in 12 residential areas around Tan Son Nhat Airport, Ho Chi Minh City, Vietnam, were determined to decrease after the epidemic outbreak. The main objective of this study has been to identify and compare how acoustic and non-acoustic factors influenced public health before and after the change. In 2019 and 2020, surveys were conducted in 12 residential areas around TSN, achieving approximately 1,200 responses. The achievement of the first effort was to establish a common pattern of noise annoyance and insomnia that corresponded to community responses to noise before and after the change. The final SEM was constructed to see whether acoustic and non-acoustic factors influence public health in different structures before and after noise reduction. It was found that the level of noise annoyance and insomnia did not decrease as expected, but rather increased in 2020.
Keywords: aircraft noise, structural equation model, annoyance, insomnia, health effects.

1. INTRODUCTION

Many research models have been proposed to explain how humans perceive noise [1]. As significant effects of noise on the community, annoyance, and insomnia may lead to mental and physical health symptoms. Annoyance is a specific combination of emotional, attitudinal, cognitive, and behavioral responses to environmental noise. It arises from a series of stress-related fight-or-flight reactions inside the human body and is typically defined as a feeling of irritation, anxiety, frustration, provocation, displeasure, or disturbance due to noise [2]. Furthermore, environmental noise at nighttime has been shown to affect sleep, both immediate physiological consequences, and self-reported sleep quality. Direct impacts of noise on sleep may negatively affect cognitive and daytime performance. It has been found that long-term exposure to nighttime noise contributes to several adverse health effects such as diabetes, cardiovascular disease, and cancer [3,4]. According to a recent European estimation, 6.5 million people have chronic high insomnia due to environmental noise, including aircraft noise [5]. The prevalence of annoyance and insomnia can be predicted based on established exposure-response relationships. However, it is recognized that acoustic quantities can only explain a proportion of the variance observed in annoyance and disturbance responses [6]. Non-acoustic factors such as living environment, sensitivity, and housing were found to moderate community responses to noise, particularly annoyances and insomnia [7]. Furthermore, recent investigations based on meta-analysis found that step changes in traffic noise cause an excess reaction [8].

The Tân Sơn Nhất (TSN) international is Vietnam's largest airport. Due to the pandemic, all flights were closed at the end of March 2020, causing an unprecedented change in the noise level around TSN airport, particularly in the acoustic environment. This event enabled a study to compare the community response before and after the change. This study will supplement data for research on the effects of decreased noise exposure due to changes in airport operational conditions, which has been studied very little [8, 9]. By conducting two surveys three months and six months after the change occurred and comparing the results with those acquired from the study conducted in August 2019, this study assesses the change's effect on the health of residents in the vicinity of the airport. Moreover, to understand human perception of the sound environment, this study focuses on the associations between acoustic and non-acoustic factors, noise annoyance, insomnia, and health consequences.

Under the significant decrease in aircraft noise in Vietnam, this research assessed the interactive effects of acoustic and non-acoustic variables on noise annoyance and insomnia.

The 2019 and 2020 surveys' causal structures for noise annoyance and insomnia were compared and used to see whether the community's health differed as a result of the change in the acoustic environment.

2. METHODS

2.1. Social survey data

Three surveys were conducted in August 2019 (1st survey, seven months before the change), June 2020 (2nd survey, three months after the change), and September 2020 (3rd survey, six months after the change). The TSN airport has two parallel east-west runways oriented in the east-west direction (07L–25R and 07R–25L). Ten sites were selected under the aircraft's landing and takeoff paths (Sites 1–10) and two control sites to the north of the airport (Sites 11 and 12) (Figure 1).

Interviewers visited approximately 1200 households and interviewed one adult from each family at selected survey sites. The same respondents from the 1st survey were revisited for the 2nd survey. The interviewers visited the same respondents in the 1st and 2nd surveys and additional respondents in the 3rd survey. The survey was designed in accordance with ISO/TS 15666 [10]. Table 1 lists the questions and scales used in all of the surveys to evaluate the outcomes of annoyance and insomnia.

Table 1: Questions and evaluation scales for measuring the outcomes of annoyance and insomnia

Annoyance Question: Thinking about the last three months or so, what number from 0 to 10 best shows how much you are bothered, disturbed, or annoyed by aircraft noise? Evaluation scale: 11-point numerical scale: from 0 (not annoyed at all) to 10 (extremely annoyed)
Insomnia Question: Please answer this question concerning your sleep: (a) Do you have any trouble with your sleep? No/Yes (b) If you answered "Yes" to the above question, please choose the corresponding alternative (Alternatives: Rarely or not at all, Once or twice a week, More than three times a week) for the following item: (1) Difficult to fall asleep; (2) When awakened during the night, it is difficult to sleep again; (3) Awakened early in the morning; (4) Do not feel as having slept well the next morning; (5) Sleepy during daytime and cannot work well; (6) Others Evaluation scale: 1: have no insomnia symptom (*), 2: have insomnia symptom (*) The respondents with insomnia symptoms are who responded affirmatively to Question (a): Do you have any trouble with your sleep? And (5) sleepy during daytime and cannot work well more than three times a week; and had experienced at least one of the other symptoms (1)– (4) more than three times in a week.

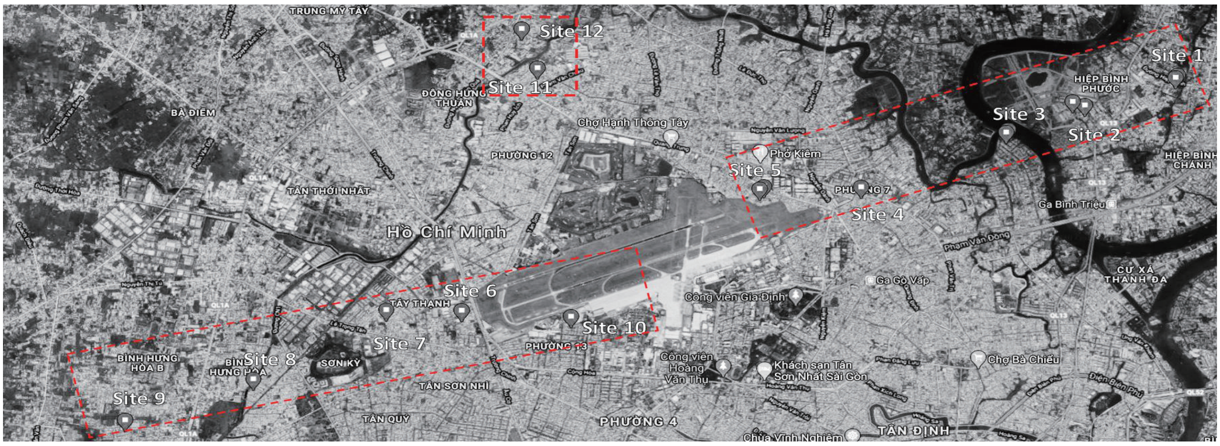

Figure 1: Map of survey sites

2.2. Model development

In this study, the correlation between non-acoustic and acoustic factors was explored by fitting them into the structural equation model (SEM). The aim was to achieve a common model for comparing the community response to noise before and after the change. The SEM model was created by integrating the questionnaire items in the socio-acoustic survey. In SEM, a latent variable was constructed by a group of observed variables that indicate the same aspect. For example, personal sensitivity was constructed from the self-reported sensitivities to several environmental conditions including noise, coldness, heat, and odors. By including both observed and latent variables, SEM effectively investigates factors that are not directly measured.

The variables used to construct the initial model are chosen from the questionnaire items. Firstly, separate models were developed for the 2019 and 2020 surveys. Then, a modification process was done to achieve a common model for both surveys. The variables used to construct the final model are listed in Table 2.

Table 2: Questions and evaluation scales for measuring moderating variables in the model.

Variables	**Question**	**Scale**
Frequency of opening bedroom windows	Do you open bedroom windows while sleeping in the dry/rainy season?	1: Rarely to 4: Always
Length of stay at home	Thinking about the last 4 four months, how long in a day do you stay at home?	1. Under 8 hours 2. 8-15 hours 3. Over 15h hours
Effects on sleep	How often do you have any trouble getting to sleep or staying asleep?	1. Seldom 2. Sometimes 3. Often
Stress	Thinking about the amount of stress in your life, would you say that most days are stressful?	0: Not at all to 10: extremely
Life satisfaction	How do you feel about your life as a whole right now?	0: Satisfied to 10: very dissatisfied
Self-reported health status	Do you usually have periodic health examinations?	1. Yes ; 2. No
Nutrition	Do you think about the nutritional balance of the diet?	1. Think a lot to 4. Don't think
Personal sensitivity	In daily life, how sensitive are you to the following environmental conditions: Noise, Coldness, Heat, Odors, Vibration	1: Not at all to 5: Extremely
Living conditions	Please evaluate your living area according to the following items: Green space, Street sceneries, View, Quietness	1: Extremely good to 5: Extremely bad

3. RESULTS

3.1. Change in noise level and community response

The average noise levels, percentage of highly annoyed (%HA), percentage of insomnia (%ISM) at each survey site, and the differences between the 2019 and 2020 surveys are shown in Table 3. During the pandemic, the day-evening-night-weighted sound pressure levels (L_{den}) and the nighttime equivalent continuous sound pressure levels (L_{night}) in the 2020 surveys have decreased significantly from the 2019 survey. The percentage of highly annoyed people (% HA) did not decrease following the decrease in noise levels in the 2020 survey. Even though the noise level decreased significantly between the 2019 and 2020 surveys, the number of respondents with insomnia increased significantly at some sites. It is necessary to develop a model that includes non-acoustic variables that can play as moderators between noise exposure and community response.

Table 3: Average noise levels, percentage of highly annoyed (%HA), percentage of insomnia (%ISM), and the number of responses at each survey site.

Site	2019		2020		2019		2020		ΔL_{den}	Δ%HA	ΔL_{night}	Δ%ISM
	L_{den}	%HA	L_{den}	%HA	L_{night}	%ISM	L_{night}	%ISM				
1	66	0	60	2	58	0	52	11.9	-6	2	-6	11.9
2	64	7.3	61	17.1	57	2.6	53	0	-3	9.8	-3	-2.6
3	64	0	59	28.6	56	6.5	51	2	-5	28.6	-5	-4.5
4	62	2	57	9.1	55	2	49	0	-6	7.1	-6	-2
5	81	3	73	7.9	73	0	66	5.3	-7	4.9	-8	5.3
6	75	18.4	69	2.4	67	6.4	61	0	-6	-16	-6	-6.4
7	69	12.5	64	0	61	0	56	0	-5	-12.5	-5	0
8	66	6.3	62	4	58	2.8	54	0	-4	-2.3	-5	-2.8
9	64	0	60	4	57	2.4	52	0	-4	4	-5	-2.4
10	67	2.2	65	3	59	2	57	3.2	-2	0.8	-2	1.2
11	47	0	43	72.5	40	3.3	36	0	-4	72.5	-4	-3.3
12	45	0	41	0	38	0	34	0	-4	0	-4	0
p-value	0.098		0.104		0.852		0.400			0.717		0.428

3.2. Comparison of Noise Annoyance models between 2019 and 2020 surveys

The sample size for noise annoyance in the 2019 and 2020 surveys was 332 and 308, respectively, after removing all responses without corresponding data from the data set. Sensitivity, living conditions, and health are three latent variables in the model. Three or two observable variables were used to evaluate each latent variable. Personal sensitivity is determined by sensitivity to noise, vibration, and cold. Stress, sleep disturbances, and nutrition concern were used to measure health variables. Living condition was determined by the view of living areas and green space for living areas. The common model established for noise annoyance in the 2019 and 2020 surveys is shown in Figure 2.

The chi-square value is statistically significant (chi-square = 224.970, $p < 0.01$). The goodness-of-fit index (GFI) and the comparative fit index (CFI) are 0.941 and 0.856 for noise annoyance. The root mean square errors of approximation (RMSEA) are 0.057 for models, respectively. The standardized regression weight annotated for each path in the models indicates the relative importance of each path and the effect size of the determinant variable on the variable in the path direction. Table 4 shows parameter estimates for the relationships mentioned above.

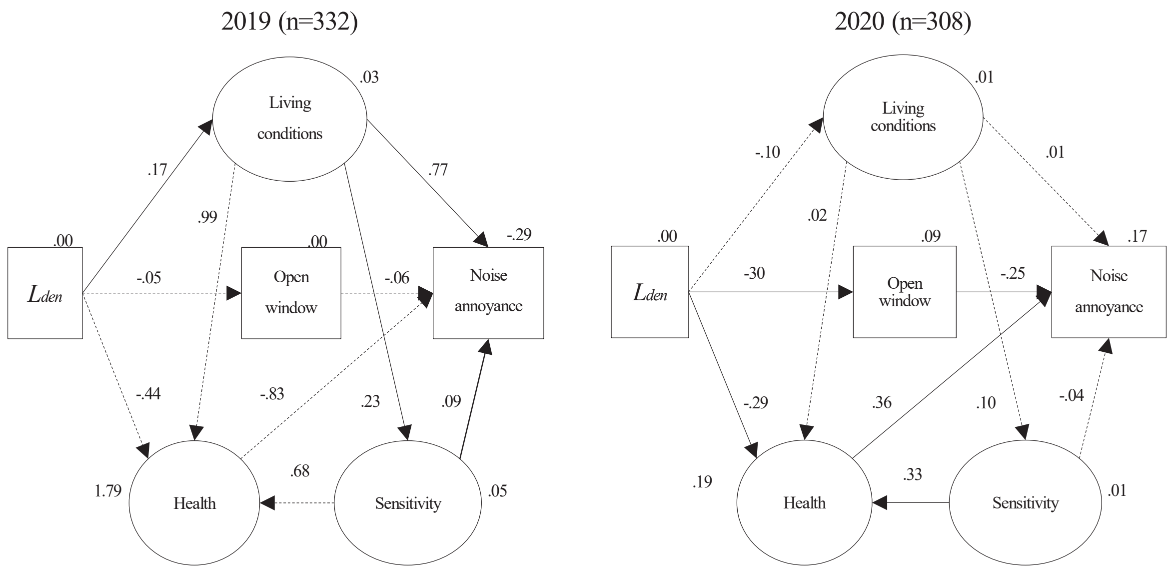

Figure 2: Estimated noise annoyance model in the 2019 and 2020 surveys, chi-square = 224.970, $p < 0.01$, df = 74, GFI = 0.941, CFI = 0.856, and RMSEA = 0.057. Statistically significant paths and standardized regression weights are annotated with ($p < 0.05$). Non-significant paths are represented with dashed lines. Explained variances are annotated above each variable.

Table 4: Parameter estimates of the noise annoyance model with the opening of the bedroom window during the dry season variable.

Parameter	2019				2020			
	Estimate	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***
Living conditions ← L_{den}	0.010	0.004	2.549	0.011	-0.005	0.004	-1.282	0.200
Sensitivity ← Living conditions	0.555	0.149	3.724	*	0.070	0.038	1.838	0.066
Health ← L_{den}	-0.001	0.001	-0.912	0.362	-0.005	0.003	-2.093	0.036
Open window ← L_{den}	-0.006	0.007	-0.851	0.395	-0.030	0.005	-5.490	*
Health ← Living conditions	0.051	0.055	0.942	0.346	0.007	0.027	0.253	0.801
Health ← Sensitivity	0.155	0.016	0.931	0.352	0.180	0.087	2.058	0.040
Annoyance ← Open window	-0.127	0.104	-1.222	0.222	-0.759	0.166	-4.565	*
Annoyance ← Health	-79.810	88.806	-0.899	0.369	5.677	2.666	2.130	0.033
Annoyance ← Sensitivity	1.863	0.614	3.033	0.002	-0.382	0.619	-0.618	0.537
Annoyance ← Living conditions	3.861	1.743	2.215	0.027	0.063	0.279	0.225	0.822

*$p < 0.001$; SE, standard error; CR, critical ratio (CR = estimate/SE).

Many people in Ho Chi Minh City have been ordered to work from home as a result of coronavirus-related restrictions that started in March 2020. This has resulted in a significant change in their lifestyle. In the second model, the observed variable of opening the bedroom window during the dry season was replaced by the length of stay at home and whether this change affected community response to aircraft noise in Ho Chi Minh City (Figure 3). The sample size for noise annoyance in the 2019 and 2020 surveys was 332 and 308, respectively, after excluding responses with blank data for variables to be used in the model. All of the above-modified relationships are summarized in Table 5.

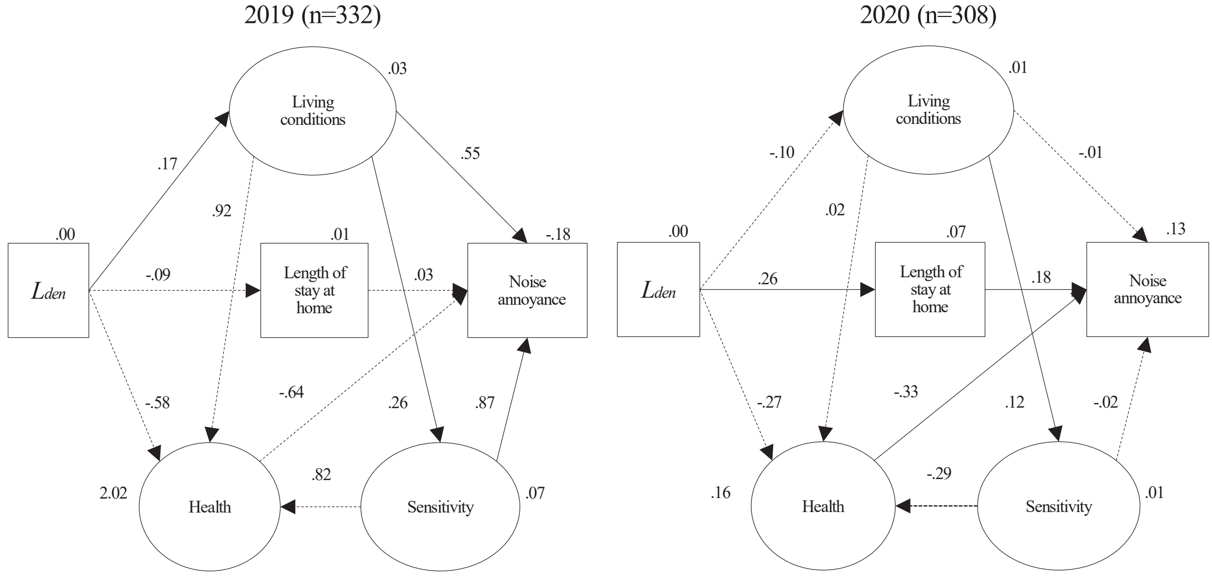

Figure 3: Estimated noise annoyance model in the 2019 and 2020 surveys, chi-square = 269.964, $p < 0.01$, df = 74, GFI = 0.935, CFI = 0.826, and RMSEA = 0.064. Statistically significant paths and standardized regression weights are annotated with ($p < 0.05$). Non-significant paths are represented with dashed lines. Explained variances are annotated above each variable.

Table 5: Parameter estimates of the noise annoyance model with the length of stay at home variable.

Parameter	2019 Survey				2020 Survey			
	Estimate	SE	CR	*p*	Estimate	SE	CR	*p*
Living conditions ← L_{den}	0.010	0.004	2.568	0.010	-0.005	0.004	-1.267	0.205
Sensitivity ← Living conditions	0.579	0.150	3.823	*	0.092	0.042	2.174	0.030
Health ← L_{den}	-0.009	0.005	-1.674	0.094	0.011	0.006	1.775	0.076
Length of stay at home ← L_{den}	-0.009	0.005	-1.663	0.096	0.018	0.004	4.725	*
Health ← Living conditions	0.246	0.143	1.722	0.085	0.003	0.053	0.050	0.960
Health ← Sensitivity	0.098	0.057	1.722	0.085	-0.308	0.183	-1.680	0.093
Annoyance ← Length of stay at home	0.086	0.135	0.635	0.525	0.793	0.241	3.287	0.001
Annoyance ← Health	-11.995	7.472	-1.605	0.108	-2.397	1.210	-1.981	0.048
Annoyance ← Sensitivity	1.915	0.519	3.688	*	-0.128	0.571	-0.224	0.823
Annoyance ← Living conditions	2.719	1.136	2.393	0.017	-0.068	0.271	-0.250	0.803

*$p < 0.001$; SE, standard error; CR, critical ratio (CR = estimate/SE).

The chi-square value (chi-square = 269.964, p 0.01) is statistically significant. For noise annoyance, the goodness-of-fit index (GFI) and the comparative fit index (CFI) are 0.935 and 0.826, respectively. The root mean square errors of approximation (RMSEA) are 0.064 for the model. The noise annoyance of the 2020 model is directly affected by the length of stay at home and indirectly by the noise level (L_{den}). In the 2020 survey, noise annoyance was directly affected by health, but not in the 2019 model.

3.3. Comparison of Insomnia models between 2019 and 2020 surveys

The final structural model for insomnia developed for the 2019 and 2020 surveys included three latent variables: sensitivity, health, and living conditions, as shown in Figure 4. Three observable variables were used to evaluate each latent variable. Individual sensitivity was determined by noise, vibration, and odor sensitivity. Stress, sleep disturbances, and nutrition were used to evaluate health. The evaluation of living conditions were influenced by the view of living spaces, green space for living areas, and street scenes. The sample size for insomnia in the 2019 and 2020 surveys was 295 and 291, respectively, after excluding answers with blank data.

The chi-square value is statistically significant (chi-square = 275.578, $p < 0.01$). The goodness-of-fit index (GFI) and the comparative fit index (CFI) are 0.927 and 0.894 for noise annoyance. The root mean square errors of approximation (RMSEA) are 0.058 for models, respectively.

Figure 4 shows that insomnia in the 2019 model was affected indirectly by noise exposure (L_{night}) through the observed variable in the dry season. In contrast, in the 2020 model, insomnia was indirectly affected by noise exposure (L_{night}) through health. Sensitivity, directly and indirectly, affects insomnia. Table 6 summarizes all of the above-modified relationships.

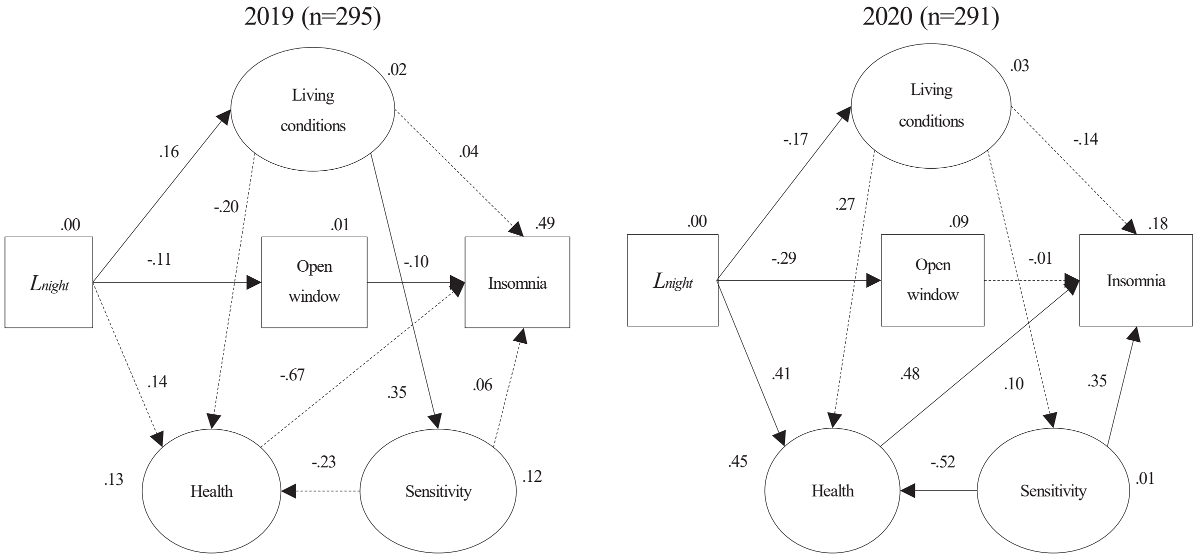

Figure 4: Estimated insomnia model in the 2019 and 2020 surveys, chi-square = 275.578, $p < 0.01$, df = 94, GFI = 0.927, CFI = 0.894, and RMSEA = 0.058. Statistically significant paths and standardized regression weights are annotated with ($p < 0.05$). Non-significant paths are represented with dashed lines. Explained variances are annotated above each variable.

Table 6: Parameter estimates of the insomnia model with the opening of the bedroom window during the dry season variable.

Parameter	2019 Survey				2020 Survey			
	Estimate	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***
Living conditions ← L_{night}	0.012	0.005	2.484	0.013	-0.014	0.005	-2.857	0.004
Sensitivity ← Living conditions	0.291	0.068	4.307	*	0.075	0.050	1.495	0.135
Health ← L_{night}	0.000	0.001	0.404	0.686	0.007	0.003	2.307	0.021
Open window ← L_{night}	-0.014	0.007	-1.872	0.061	-0.029	0.006	-5.231	*
Health ← Living conditions	-0.007	0.018	-0.405	0.686	0.059	0.032	1.812	0.070
Health ← Sensitivity	-0.010	0.026	-0.406	0.685	-0.152	0.066	-2.302	0.021
Insomnia ← Open window	-0.043	0.019	-2.236	0.025	-0.006	0.029	-0.222	0.825
Insomnia ← Health	-13.148	32.090	-0.410	0.682	0.286	0.101	2.844	0.004
Insomnia ← Sensitivity	0.052	0.053	0.977	0.328	1.347	0.647	2.082	0.037
Insomnia ← Living conditions	0.027	0.041	0.652	0.514	-0.082	0.050	-1.642	0.100

*$p < 0.001$; SE, standard error; CR, critical ratio (CR = estimate/SE).

Similarly, we constructed a new model by changing the observed variable from opening the bedroom window during the dry season to the length of stay at home, as shown in Figure 5. The sample size for insomnia in the 2019 and 2020 surveys was 295 and 291, respectively, after removing all responses without corresponding data from the data set. The chi-square value is statistically significant (chi-square = 279.004, p < 0.01). The goodness-of-fit index (GFI) and the comparative fit index (CFI) are 0.928 and 0.892 for insomnia. The root mean square errors of approximation (RMSEA) are 0.058 for models, respectively. In the 2019 model, observed and latent variables had no direct or indirect influence on insomnia. In contrast, in the 2020 model, insomnia was indirectly affected by noise exposure (L_{night}) through health. Insomnia is influenced by sensitivity both directly and indirectly. All of the above-modified relationships are summarized in Table 7.

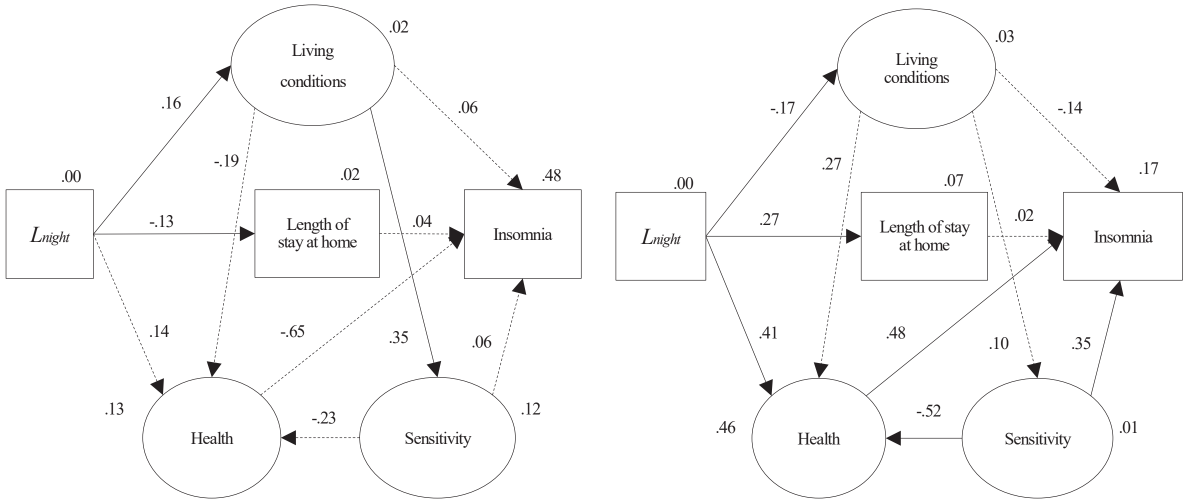

Figure 5: Estimated insomnia model in the 2019 and 2020 surveys, chi-square = 279.004, p < 0.01, df = 94, GFI = 0.928, CFI = 0.892, and RMSEA = 0.058. Statistically significant paths and standardized regression weights are annotated with (p < 0.05). Non-significant paths are represented with dashed lines. Explained variances are annotated above each variable.

Table 7: Parameter estimates of the insomnia model <u>with the length of stay at home variable.</u>

Parameter	**2019**				**2020**			
	Estimate	**SE**	**CR**	***p***	**Estimate**	**SE**	**CR**	***p***
Living conditions ← L_{night}	0.012	0.005	2.487	0.013	-0.014	0.005	-2.857	0.004
Sensitivity ← Living conditions	0.291	0.067	4.307	*	0.075	0.050	1.494	0.135
Health ← L_{night}	0.000	0.001	0.427	0.669	0.007	0.003	2.282	0.023
Length of stay at home ← L_{night}	-0.013	0.006	-2.234	0.025	0.017	0.004	4.839	*
Health ← Living conditions	-0.008	0.018	-0.429	0.668	0.058	0.032	1.799	0.072
Health ← Sensitivity	-0.011	0.025	-0.430	0.667	-0.151	0.066	-2.278	0.023
Insomnia ← Length of stay at home	0.020	0.025	0.820	0.412	0.014	0.045	0.320	0.749
Insomnia ← Health	-12.162	27.965	-0.435	0.664	0.285	0.100	2.838	0.005
Insomnia ← Sensitivity	0.054	0.053	1.008	0.313	1.347	0.655	2.057	0.040
Insomnia ← Living conditions	0.047	0.041	1.136	0.256	-0.083	0.050	-1.661	0.097

*p < 0.001; SE, standard error; CR, critical ratio (CR = estimate/SE).

4. SUMMARY

The structural equation model (SEM) proposed in this study indicates how non-acoustic and acoustic variables are related to defining the response to aircraft noise in residential areas near the airport. For the 2019 and 2020 surveys, a common model was developed to compare the structures of community response to noise before and after the change. Noise exposure had indirect effects on noise annoyance and insomnia through non-acoustic factors, according to the models' parameter estimates. This result indicates that noise annoyance and insomnia are influenced by non-acoustic factors more than noise exposure.

The second model included the length of stay at home variable to see whether the residents of Ho Chi Minh City's response to noise was influenced by the pandemic's lifestyle change. It is worth noting that the paths linking the length of stay at home starting from noise and toward annoyance are significant in the 2020 model, indicating the fact that having to spend longer time at home increases the community response to noise. In the 2019 annoyance model, living conditions and sensitivity were significant factors, while in the 2020 model, health and sensitivity were significantly linked to insomnia. Furthermore, in the 2020 survey, health has a significant effect on noise annoyance and insomnia. The finding that health can increase annoyance and insomnia could explain why the percentage of people who are highly annoyed and have insomnia did not decrease in combination with the significant decrease in aircraft noise.

5. ACKNOWLEDGEMENT

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REFERENCES

[1] T. Yano et al., Comparison of community response to road traffic noise in Japan and Sweden — part II: path analysis, J. Sound Vib., 250(1), 169–174, (2009).

[2] Guski, R., Schreckenberg, D., & Schuemer R. (2017). WHO Environmental noise guidelines for the European Region: a systematic review on environmental noise and annoyance. International Journal of Environmental Research and Public Health, 14(12), 1539.

[3] Daiber, A., et al., Environmental noise induces the release of stress hormones and inflammatory signaling molecules leading to oxidative stress and vascular dysfunction—Signatures of the internal exposome. BioFactors, 2019. 45(4): p. 495-506.

[4] Münzel, T., et al., Adverse cardiovascular effects of traffic noise with a focus on nighttime noise and the new WHO noise guidelines, in Annual Review of Public Health. 2019. p. 309-328.3. European Environment Agency., Environmental noise in Europe - 2020. EEA Report No 22/2019. 2019.

[5] Basner, M et al., Aircraft Noise Effects on Sleep-Results of a Pilot Study Near Philadelphia International Airport. Int J Environ Res Public Health, 2019. 16(17).

[6] R. Guski, Community response to environmental noise, in Transportation Noise Reference Book, P.M. Nelson, Ed. (Butterworths Univ. Press, Cambridge, 1987), chap. 4.

[7] H.M.E. Miedema and H. Vos, Demographic and attitudinal factors that modify annoyance from transportation noise, J. Acoust. Soc. Am., 105, 3336–3344, (1999).

[8] Brink, M et al., Annoyance responses to stable and changing aircraft noise exposure. J. Acoust. Soc. Am. 2008, 124, 2930–2941.

[9] Fidell, S.; Silvati, L.; Haboly, E. Social survey of community response to a step-change in aircraft noise exposure. J. Acoust. Soc. Am. 2002, 111, 200–209.

[10] ISO/TS 15666:2003, Acoustics — Assessment of noise annoyance by means of social and socio-acoustic surveys.