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# Assessment of health effects of aircraft noise on residents living around Noi Bai International Airport

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## ABSTRACT

**The number of studies on the impact of noise on health is very limited especially for people living around major airports in developing countries. Two surveys on health effects of aircraft noise were conducted at 13 sites around Noi Bai International Airport (HNBIA) in November 2017 and August 2018. The surveyed contents included aircraft noise exposure levels, noise annoyance, sleep disturbance and general health indicators such as Body Mass Index (BMI), blood pressure, etc. Exposure levels were obtained by field measurement and noise map estimation. Community responses were investigated by face-to-face interview. Blood pressure of the respondents was assessed by self-reported method and measurement. Comparisons of respondents with high blood pressure and insomnia ratios at**

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**different noise exposure level ranges showed that there is no significant association between ratios of hypertension and noise exposure levels ($L_{den}$) but a significant exposure-response relationship was found between night-time noise exposure levels and insomnia. This result suggested that a restriction on nighttime flight operation and a specific regulation for aircraft noise limit should be considered to protect the health of residents living around airports for sustainable and balanced development of air transport in Vietnam.**

**Keywords:** Aircraft Noise, Health Effect.
**I-INCE Classification of Subject Number:** 30

## 1. INTRODUCTION

The rapid growth of aviation transport without a noise control policy causes serious problems to human health, especially for people living around airports in developing countries. Disturbed sleep caused by night-time aircraft noise was found to damage blood vessels and increase the level of stress hormones in the body [1]. Increasing exposure to noise is potential pathway to high blood pressure, heart and circulatory disease over the long term [1]. However, most of the studies on health effects of aircraft noise exposure were conducted in developed countries (e.g., Europe and North American). This issue in developing countries should be paid more attention despite that concerns for health and environmental problems are limited.

In this study, the surveys on health impacts of aircraft noise, such as noise annoyance, insomnia, Body Mass Index, blood pressure, are conducted around Noi Bai International Airport (HNBIA), the second busiest airport in Vietnam. After the newly-built terminal was opened and went into full operation at the end of December 2014, the airport's capacity had been boosted by 10 million passengers a year and had increased the ability to serve more flights a day. This led to health consequences caused by increasing aircraft noise levels for residents living around HNBIA. In the previous surveys on step change effects of aircraft noise conducted around HNBIA, the exposure changes due to increase in flight operation and the community responses to such a change were investigated [2].

By conducting two surveys in November 2017 and August 2018, in addition to researching the community responses, the impacts of noise on residents' health were assessed. This study aims to (1) investigate the relationship between aircraft noise exposure levels and general health; and (2) clarify whether the aircraft noise actually causes cardiovascular disease to residents living in the vicinity of the airport. This study is expected to provide practical investigation methods and knowledge about the impact of noise on public health, especially those living around airports in developing countries.

## 2. METHODS

### 2.1 Survey sites

This study was conducted at 13 survey sites which were selected from the previous surveys in 2014 and 2015 (Figure 1). Sites A1-A11 were located under the major flight routes of the aircrafts and affected by noise from the noisiest level to almost unconceivable levels. Sites A1-A6 were on the arrival side, while Sites A7-A11 were on the take-off side. Two reference sites A12 and A13 were assumed to be unaffected by aircraft noise but have the same living conditions as the other sites [3].

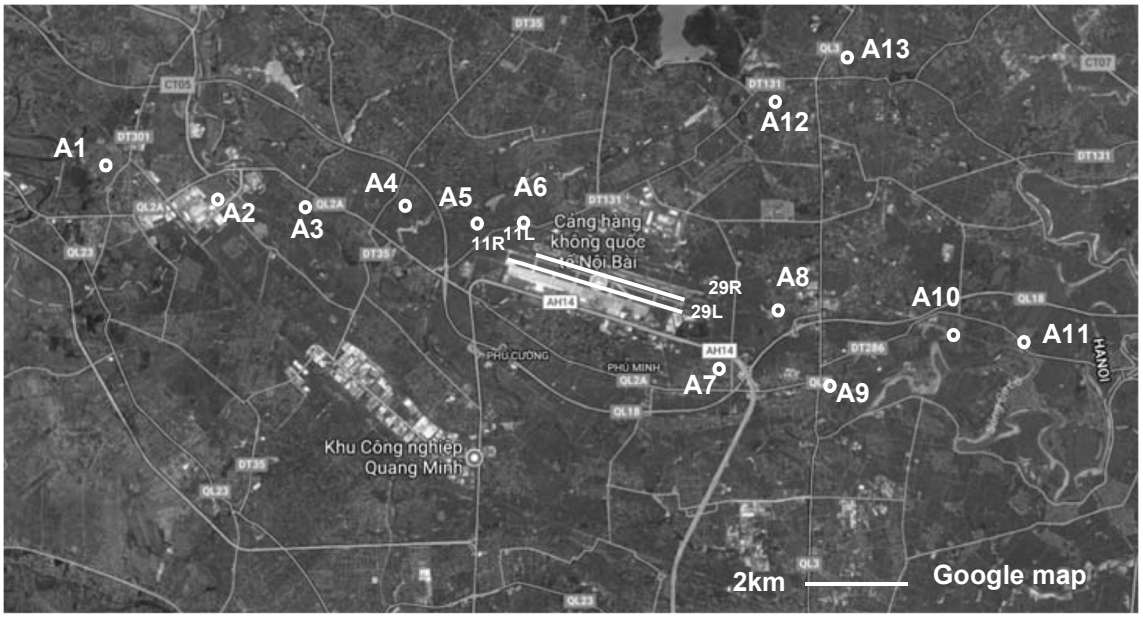


*Figure 1. Map of survey sites*

**2.2 Noise exposure measurement**

In Round 1, one house at each survey site was selected to install measurement equipment. A negotiation was made with the house owner to be able to install and maintain the device for automatic and continuous measurement in 7 days. In Round 2, instead of field measurement, noise levels were obtained from a noise contour map calculated with operation data provided by the airtport managers. The number of flight events during the two surveys were counted based on flight log data provided by the Civil Aviation Authority of Vietnam (CAAV).

**2.3 Health surveys**

The health surveys were conducted around HNBIA in November 2017 (Round 1) and August 2018 (Round 2). Since data of regular health check of respondents living at the survey sites were not available, the survey items relating to the respondents' health status were included in the questionnaires. In Round 1, all health data were collected by self-reporting method. In Round 2, measurements of the blood pressure, heart rate, etc. indexes were added.

In Round 1, face-to-face interviews were conducted to obtain data of community responses and health. In Round 2, interview was still conducted in the same way as in Round 1, but the questionnaire was changed by adding more health related questions instead of questions on attitudes and housing factors, etc. (Table 1). In Round 2, a blood pressure measurement was performed after the interview was completed.

*2.3.1 Contents of the questionnaires*

As shown in Table 1, in the questionnaire used in Round 1, in addition to questions about personal information, such as gender, age, occupation, environmental conditions, quality of life and housing structure of respondents, etc., the questions about the health indexes including Body Mass Index (BMI) and blood pressure were added. In Round 2, additional questions about medication information were included referring High Blood Pressure Questionnaire of Community Health Plan of Washington [4]. Both surveys were composed of questions concerning annoyance and sleep problems such as sleep disturbance and insomnia.

*Table 1 – Questionnaire items of each survey*

| *Round 1* | | *Round 2* | |
|---|---|---|---|
| 1- 4 | Housing factors | 1 - 5 | Demographic variables |
| 5, 6, 31 | Residential environment | 6 | Residential environment |
| 7 -15 | Annoyance | 7 - 9 | Health status |
| 16 - 20 | Sensitivities | 10, 11 | Sensitivities, Stress |
| 21 - 23 | Attitudes about transportation | 12 | BMI |
| 24 - 28 | Demographic variables | 13 - 17 | Medical issues |
| 29 | Participated or not participated in previous surveys | 18 - 21 | Blood pressure |
| 30 | BMI, blood pressure | 23 - 25 | Living habits |
| 32 - 40 | Structure of the house | 26, 27 | Sleep disturbance |
| 41 | Family subject (Father, Mother, or others) | 28 - 30 | Annoyance |

The following questions relating to health status were added in Round 2. They aim to collect information about pathology of the residents, especially those relating and affecting blood pressure index .

15. Are there any medical problems you are being treated for?
1) No ☐
2) Yes ☐
If yes, what are medical problems? _____
19. In the last 6 months, do you have any problems with blood pressure?
1) No ☐
2) Yes ☐

Living habit is also one of the factors affecting health. The floor level of a bedroom in a house is assumed to affect annoyance and insomnia, while smoking and drinking alcohol are assumed to cause high blood pressure [5]. The following questionnaire items were included to mention such concern:

5. How many floors does your house have? _____ floors
At which floor are you usually sleeping?
23. Do you often smoke cigarettes?
1) No ☐
2) Yes ☐
24. Do you often drink alcohol?
1) No ☐
2) Yes ☐

*2.3.2 Blood pressure measurement*

Since Round 2, in addition to the self-reported method, direct blood pressure measurement with specialized devices were conducted. Two blood pressure meter used in Round 2 were OMRON HEM-6324T and OMRON HEM-6320. The OMRON wrist monitor uses the oscillometric method of blood pressure measurement. This means the monitor detects the blood's movement through the artery in people's wrist and converts the movements into a digital reading. Blood pressure measurement was done right after the interview with the questionnaire.

Respondents was instructed to be relaxed, spend a rest, and adjust the sitting posture before starting a measurement. The blood pressure meter was worn on the wrist of the respondent which was located on par with the heart's position. Measurements were repeated three times for each participant with a break of about 5 minutes in between. Both the investigators and participants remained still and keep quiet during the measurements.

## 3. RESULTS

### 3.1 Demographic data

A total of 623 and 132 responses were obtained in Round 1 and Round 2, respectively. Table 2 shows that there are differences in demographic data between Round 1 and Round 2. More respondents of "Student, housewife, retired, unemployed" in Round 2 than Round 1. And the proportion of respondents living in the area for more than 10 years in Round 2 is less than that of Round 1.

*Table 2 – Comparison of demographic data between Round 1 and Round 2*

| | | Round 1 | Round 2 | Vietnam (2018) |
|---|---|---|---|---|
| Number of respondents | | 623 | 132 | |
| Response rate (%) | | 95.8 | 83.3 | |
| Gender | Male | 47.7 | 54.1 | 49.5 |
| | Female | 52.3 | 45.9 | 50.5 |
| Age | 20s-50s | 75.5 | 82.2 | 88.6 |
| | ≥60s | 24.5 | 17.8 | 11.4 |
| Occupation | Employment | 51.4 | 27.1 | 56.5 |
| | Student, housewife, retired, unemployed | 48.6 | 72.9 | 43.5 |
| Length of residence | 0-9 years | 14.3 | 53.5 | |
| | 10 years or more | 85.7 | 46.5 | |

### 3.2 Average daily noise exposure

Table 3 shows the average number of flights divided in day, evening and night time periods in the two surveys. Although the total number of flights increased slightly during the day time, there is a significant change with that of evening and night time periods. While the number of flights in the evening decreased from 82 to 25, that of night-time period increased nearly 2.5 times, from 74 to 171.

Table 4 shows noise exposure levels measured at the survey in 2017 and estimated for the survey in 2018. Sites A5 and A8 have the highest average noise levels. The noise level of Site A6 generated by the noise map of the 2018 survey is comparable to the field measurement results of the surveys conducted in 2014 and 2015. In Round 1, the noise level measured at Site A6 is about 10dB lower than the average noise level measured and calculated for the other surveys at HNBIA. Considerring a specific condition of measurement setting location when the house was built one floor higher at Site A6 that obstruct incidence of aircraft noise, measured noise level obtained at Site A6 was resplaced by estimated noise level generated by noise map.

*Table 3 – Average number of flight events*

| *Period* | *Flight path* | *2017* | *2018* |
|---|---|---|---|
| *Day (6:00-18:00)* | Arrival side | 120 | 141 |
| | Departure side | 135 | 123 |
| | Total | 255 | 264 |
| *Evening (18:00-22:00)* | Arrival side | 47 | 12 |
| | Departure side | 35 | 13 |
| | Total | 82 | 25 |
| *Night (22:00-6:00)* | Arrival side | 38 | 77 |
| | Departure side | 36 | 94 |
| | Total | 74 | 171 |
| *Total* | Arrival side | 205 | 230 |
| | Departure side | 206 | 230 |
| | Total | 411 | 460 |

*Table 4 – Noise levels measured and estimated for the two surveys*

| | $L_{night(22:00\text{-}6:00)}$ (dB) | | $L_{den}$ (dB) | |
|---|---|---|---|---|
| | Round 1 | Round 2 | Round 1 | Round 2 |
| A1 | 47 | 45 | 55 | 52 |
| A2 | 47 | 48 | 54 | 55 |
| A3 | 54 | 53 | 62 | 60 |
| A4 | 55 | 54 | 63 | 61 |
| A5 | 69 | 64 | 76 | 71 |
| A6 | 55 | 57 | 64 | 64 |
| A7 | 57 | 59 | 65 | 65 |
| A8 | 59 | 58 | 66 | 65 |
| A9 | 58 | 58 | 65 | 65 |
| A10 | 53 | 52 | 60 | 58 |
| A11 | 52 | 50 | 59 | 57 |
| A12 | 30 | | 38 | 40 |
| A13 | 29 | | 38 | 37 |

### 3.4 High blood pressure rate

*3.4.1 Percentage of high blood pressure*

In this study, the respondents whose blood pressure exceeded the corresponding average blood pressure were considered to have high blood pressure. Table 5 show the average blood pressure categorized by sex and age according to American Heart Association. Table 6 and Figure 4 show the comparison of high blood pressure rates between Round 1 and Round 2. In Round 1, blood pressure data were collected by self-reported method. It is worth noting that many respondents did not know their blood pressure and skip reporting this data.

*Table 5. Average blood pressure by age and gender (American Heart Association)*

| Age | 15-18 | 19-24 | 25-29 | 30-35 | 36-39 | 40-45 | 46-50 | 51-55 | 56-60 | >60 |
|---|---|---|---|---|---|---|---|---|---|---|
| Female | 117/77 | 120/79 | 120/80 | 122/81 | 123/82 | 124/83 | 126/84 | 129/85 | 130/86 | 134/87 |
| Male | 120/85 | 120/79 | 121/80 | 123/82 | 124/83 | 125/83 | 127/84 | 128/85 | 131/87 | 135/88 |

*Table 6. Percentage of high blood pressure*

| | Round 2 | | Round 1 | |
|---|---|---|---|---|
| | Answer | %HBP | Answer | %HBP |
| A1 | 10 | 50 | 46 | 41 |
| A2 | 10 | 70 | 12 | 67 |
| A3 | 10 | 80 | 17 | 0 |
| A4 | 10 | 80 | 2 | 100 |
| A5 | 10 | 70 | 26 | 81 |
| A6 | 10 | 90 | 0 | |
| A7 | 10 | 40 | 13 | 38 |
| A8 | 10 | 50 | 4 | 50 |
| A9 | 10 | 40 | 5 | 40 |
| A10 | 10 | 60 | 18 | 17 |
| A11 | 10 | 70 | 5 | 100 |
| A12 | 10 | 30 | 23 | 65 |
| A13 | 10 | 80 | 18 | 33 |
| Total | 130 | 62.3 | 189 | 47 |

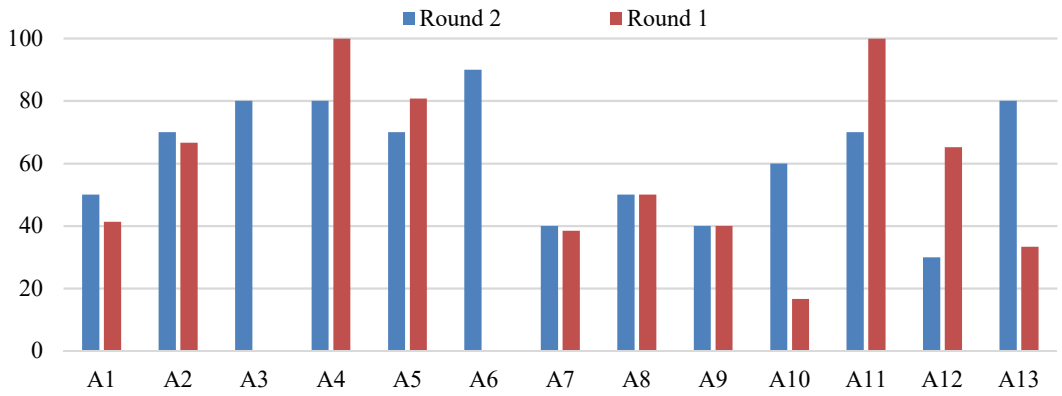


*Figure 4. Percentage of high blood pressure*

*3.4.2 Moderating factors of high blood pressure prevalance*

Nominal logistic model was applied to investigate moderating factors of high blood pressure prevalence. In this study, the factor such as age, general health status, stress, noise sensitivity, BMI, medical issues, drinking, smoking, and aircraft noise exposure was assumed to moderate blood pressure. The response data of each factor, except noise level, was categorized into "positive" and "negative". "Negative" category included responses that possibly cause high blood pressure. For example, age of over 50, BMI ≥

30 or overweight, "very" or "extremely" sensitive to noise, often drink alcohol and smoke, have blood pressure problems in the last 6 months, was classified as "negative". Particularly in an open question about the respondents' medical history, all responses that mentioned diseases that can lead to hypertention such as diabetes, thyroid, cardiovascular, vestibular, blood lipids, and prostate hypertrophy, were categorized into "negative." The results shown in Table 7 and Table 8 indicated that "age" and "often drinking alcohol" are the biggest influencing factors causing the high blood pressure condition. Meanwhile, the association between aircraft noise level and risk of high blood pressure was not significant.

*Table 7. Multiple logistic regression showing risk factors of high blood pressure*

| *Term* | *Odds Ratio* | *Prob>ChiSq* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|
| $L_{den}$ | 1.02412 | 0.3953 | 0.969356 | 1.081978 |
| Age [1-0] | 0.2400337 | 0.0083* | 0.0832531 | 0.6920607 |
| Health status [1-0] | 1.2254866 | 0.7002 | 0.4352704 | 3.4503094 |
| Noise sensitivity [1-0] | 2.3893915 | 0.0946 | 0.8604332 | 6.6352526 |
| Stress [1-0] | 1.2821452 | 0.7301 | 0.3124383 | 5.2615064 |
| BMI [1-0] | 1.3443494 | 0.6499 | 0.3746401 | 4.8240311 |
| Medical problems [1-0] | 1.1271744 | 0.8324 | 0.3720333 | 3.415076 |
| Smoke [1-0] | 1.8378271 | 0.1826 | 0.7509785 | 4.4976099 |
| Drink alcohol [1-0] | 0.2663392 | 0.0085* | 0.0994994 | 0.7129343 |
| Annoyance [1-0] | 1.1880178 | 0.7631 | 0.3875305 | 3.6420004 |
| Insomnia [1-0] | 1.194929 | 0.7319 | 0.4313613 | 3.3101149 |

*Table 8. The influence of each factor on blood pressure*

| *Source* | *Log Worth* | *P value* |
|---|---|---|
| Age | 2.218 | 0.00605 |
| Drink alcohol | 2.178 | 0.00664 |
| Noise sensitivity | 1.039 | 0.09138 |
| Smoke | 0.749 | 0.17837 |
| $L_{den}$ | 0.406 | 0.39300 |
| BMI | 0.188 | 0.64832 |
| Health status | 0.155 | 0.69976 |
| Stress | 0.138 | 0.72790 |
| Insomnia | 0.136 | 0.73143 |
| Annoyance | 0.117 | 0.76307 |
| Medical problems | 0.080 | 0.83224 |

### 3.3 Association between noise exposure level and community responses

Figures 2 and 3 show the logistic regression relationship between the noise levels and the percentage of highly annoyed respondents and the percentage of respondents suffering from insomnia of the two surveys. Between Round 1 and Round 2, there is a similarity between 2 curves. The relationships between the percentage of highly annoyed and $L_{den}$ of the two survey are consisntent. However, the relationship for percentage of insomnia and $L_{Aeq,night}$ of Round 2 is significantly higher than that of Round 1. In other words, more repondents reported sympton of sleep effects in Round 2 than Round 1. This result is consistent with the increase of night flight operation around HNBIA in 2018.

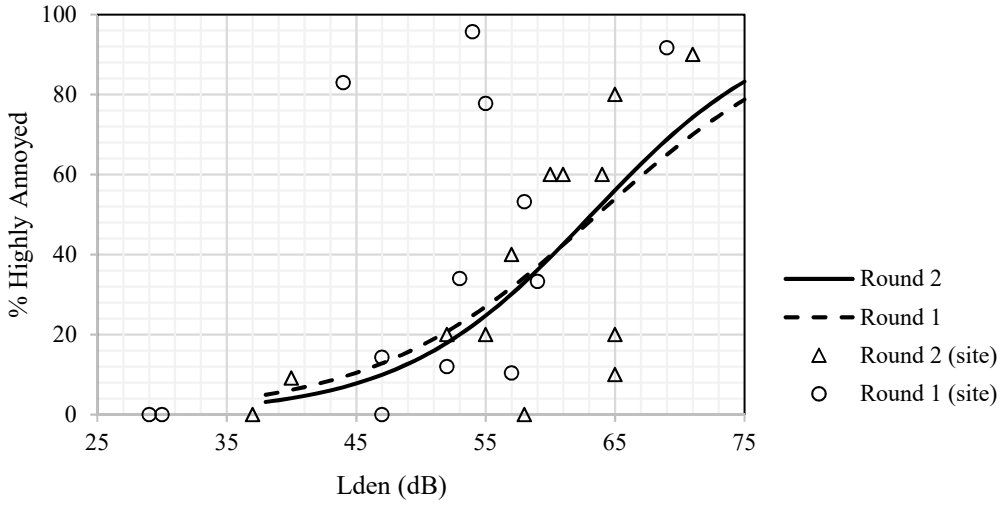


*Figure 2. The relationship between the percentage of highly annoyed and $L_{den}$*

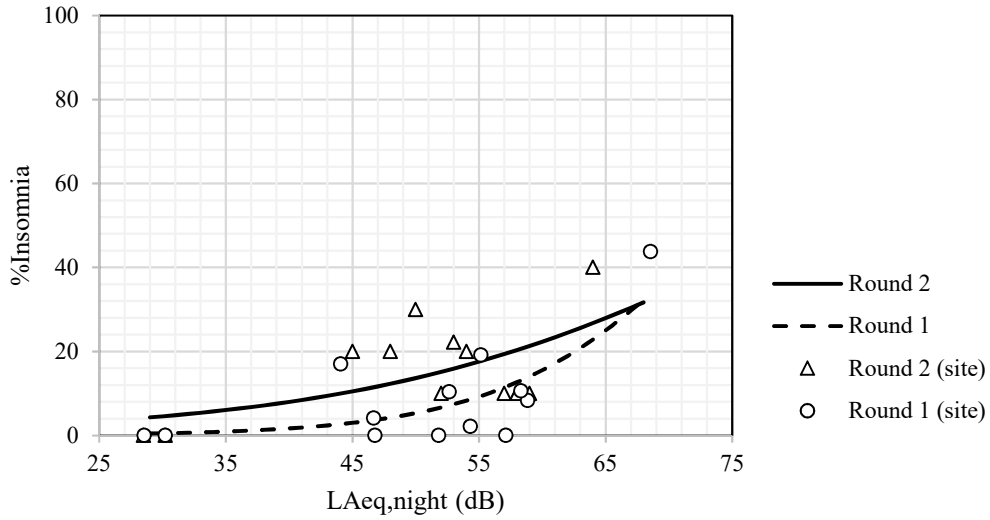


*Figure 3. The relationship between the percentage of insomnia and $L_{Aeq,night}$*

## 4. CONCLUSIONS

This study is the first effort to assess health consequense of aircraft noise at major airports in Vietnam. The results show the high rate of high blood pressure among residents living at the airport but no significant association with noise levels was found. The higher rate of insomnia was found with the survey period when night flight operation was enhanced. For further studying the impact of noise on general health of resident living around the airport areas in Vietnam, investigation based on reliable method of collecting health data is needed.

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