

INTRODUCTION

Aircraft noise is one of the most significant environmental impacts of aviation and is a major concern for communities living near airports. Continuous exposure to noise can cause various health effects, ranging from hearing impairment and sleep disturbance to an increased risk of cardiovascular disease. Aircraft noise not only causes auditory effects but also non-auditory effects that can affect long-term health.¹

The World Health Organization (WHO) established environmental noise guidelines in 2018, recommending that aircraft noise levels not exceed 45 dB Lden for daytime exposure and 40 dB Lnight for nighttime exposure.² In Europe, more than 110 million people (>20% of the population) are exposed to transportation noise above the 55 dB Lden threshold. In the United States, more than 100 million people are estimated to be at risk of health effects due to noise exposure.^{3, 4, 5, 6}

At the national level, Indonesia has a regulation, Minister of Environment Decree No. 48 of 1996, which sets the noise quality standard for residential areas at 55 dB. However, research on the impact of aircraft noise on public health in Indonesia is still very limited, especially at rapidly developing regional airports.

Tampa Padang Airport in Mamuju, West Sulawesi, has been operating commercially since 2014 and serves domestic flights with increasing frequency. The Bebanga sub-district, located near the airport, is an area with the highest potential for noise exposure. Several international studies have documented the impact of aircraft noise, such as Park et al. (2024) at Baltimore Washington

International Airport, which found an increase in the economic burden of health, and Gong et al. (2024) at Heathrow Airport, which showed a link between noise exposure and the risk of cardiovascular disease.^{7, 8}

Although evidence of the impact of aircraft noise has been documented in developed countries, similar research in Indonesia, particularly at regional airports such as Tampa Padang, has never been conducted. This study is the first to investigate aircraft noise levels and their health impacts at Tampa Padang Airport, with the objectives of: (1) measuring aircraft noise levels, and (2) assessing their impact on public health in terms of hearing impairment, sleep disturbance, and psychological effects.

MATERIALS AND METHODS

This study used a descriptive design with a mixed methods approach that combined quantitative noise measurements and qualitative health surveys. The study was conducted in Bebanga Village, Kalukku District, Mamuju Regency, West Sulawesi Province in January 2025.

The study population consisted of all 312 households residing in Bebanga Village. The sampling technique used purposive sampling with the following inclusion criteria: (1) minimum age of 20 years, (2) minimum residence of 10 years, (3) willingness to be a respondent, and (4) no history of congenital hearing impairment. Based on these criteria, 94 respondents (78 men, 16 women) were obtained.

Noise measurements were taken at three locations: Point 1 ($\pm 500\text{m}$ from the runway), Point



2 ($\pm 750\text{m}$), and Point 3 ($\pm 1000\text{m}$). Measurements were taken using a Sound Level Meter calibrated according to the SNI 7231:2009 standard with the following procedure: 1) Measurement time: 08.00-16.00 WITA (airport operating hours); 2) Replication: 3 measurements per point for each aircraft; 3) Weather conditions: clear, wind speed $< 5 \text{ m/s}$; 4) Background noise handling: measurements were taken at least 10 dB above background noise; 5) Device position: 1.2-1.5 meters above ground level, microphone directed towards the source.

Health impact assessment used a structured questionnaire that had been tested for validity ($r=0.72-0.89$) and reliability (Cronbach's $\alpha=0.84$). Hearing impairment assessment was subjective based on respondent reports, not audiometry. Data were collected through face-to-face interviews.

Data were analyzed descriptively using frequency distribution and percentages. Noise levels were compared with the quality standards of the Decree of the Minister of Environment No. 48 of 1996 and WHO guidelines.¹⁰

RESULTS

The study involved 94 respondents with characteristics as shown in Table 1. The majority of respondents were male (83%), aged 35-44 years (52.2%), had lived in the area for 10-12 years, and lived within 500-1000 meters from the airport (77.7%).

Noise measurement results (Table 2) show variations based on location, aircraft type, and flight phase. The highest noise level was recorded for

Boeing aircraft landing at Point 1 (92.1 dB), while the lowest was for Boeing aircraft landing at Point 3 (64.5 dB). The landing phase consistently produced higher noise levels than takeoff. All measurement results exceeded the residential zone quality standard (55 dB) and WHO guidelines (45 dB Lden).

Table 1. Distribution of Respondent Characteristics in the Residential Environment of Tampa Padang Airport in Bebanga Village, Kalukku District, Mamuju Regency in 2025

Features	n	%
Gender		
Male	78	83
Women	16	17
Age		
20 – 24	1	1,1
25 – 29	11	11,7
30 – 34	11	11,7
35 – 39	26	27,7
40 – 44	23	24,5
45 – 49	15	16
>49	7	7,4
Length of Stay		
10 Years	42	44,7
11 Years	12	12,8
12 Years	40	42,6
Home Distance		
<500 meters	17	18,1
500 – 1000 meters	73	77,7
> 1000 meters	4	4,3

Source: Primary Data, 2025

Table 2. Distribution of Aircraft Noise Measurement Results in the Residential Environment of Tampa Padang Airport in Bebanga District, Kalukku District, Mamuju Regency in 2025

Measurement Point	Landing (dB)	Take off (dB)
ATR Aircraft		
Point 1 ($\pm 500\text{m}$)	86,6	77,3
Point 2 ($\pm 750\text{m}$)	70	70,5
Point 3 ($\pm 1000\text{m}$)	75,8	77,3
Pesawat Boeing		
Point 1 ($\pm 500\text{m}$)	92,1	75,1
Point 2 ($\pm 750\text{m}$)	70,2	77,3
Point 3 ($\pm 1000\text{m}$)	64,5	70,1
Quality Standards	55 (Indonesia) / 45 (WHO)	

Source: Primary Data, 2025



The health impact assessment (Table 3) shows that 78 respondents (83%) did not experience hearing impairment, 15 respondents (16%) experienced mild impairment, and 1 respondent (1.1%) experienced moderate impairment. Regarding sleep disturbance and psychological stress, all respondents (100%) reported no impairment. Respondents stated that they had become accustomed to the noise from aviation activities.

Table 3. Distribution of Respondents' Health Impacts

Health Impact	n	%
Hearing Loss*		
No distractions	78	83
Mild Disorders	15	16
Moderate Disturbance	1	1
Sleep Disorders		
No distractions	94	100
There is a disruption	0	0
Stress		
No distractions	94	100
There is a stress disorder	0	0
Psychological Disorders		
No distractions	94	100
There is a psychological disorder	0	0

*Based on the respondent's subjective report, not audiometric examination.

Source: Primary Data, 2025

DISCUSSION

According to the WHO (2018), the productive age group has a higher risk of noise impact due to more intense daily activities. The length of stay of respondents, which reached 10-12 years, indicates a long duration of exposure. A longitudinal study by Jacuzzi et al. (2024) shows that cumulative noise exposure can cause progressive health effects.¹² The majority of respondents (77.7%) lived within 500-1000 meters of the airport, which is classified as a high noise zone according to International Civil

Aviation Organization (ICAO) guidelines. This distance places residents at significant risk of various health effects due to chronic noise exposure.¹³ ICAO research also acknowledges that "individuals exposed to characteristic noise tend to become accustomed to it, and the exposure-response curve derived in the field (where subjects have been frequently exposed to noise for many years) is much flatter than that derived in unfamiliar laboratory settings."¹⁴

The measured noise levels (64.5-92.1 dB) all exceed Indonesia's residential zone quality standard (55 dB) and WHO guidelines (45 dB Lden). The landing phase produced higher noise levels than takeoff, consistent with the literature showing that aircraft engines in landing configuration (flaps extended, landing gear down) produce higher aerodynamic noise.¹¹

Boeing aircraft produced higher noise levels than ATR aircraft, which can be explained by differences in size and engine configuration. These findings imply that an increase in the frequency of large aircraft flights in the future needs to be anticipated with adequate mitigation strategies.

The prevalence of hearing impairment of 17.1% (16% mild, 1.1% moderate) indicates a health impact, albeit relatively limited. Basner et al. (2014) explain that exposure to noise above 65 dB can cause irreversible damage to the hair cells of the cochlea.¹ The majority of respondents (83%) did not experience impairment, possibly because the relatively low frequency of flights allowed for recovery periods for the auditory system. First, the relatively low frequency of flights allowed for recovery periods for the auditory system. Second,



the intermittent nature of aircraft noise differs from continuous occupational noise exposure. However, it should be noted that noise-induced hearing loss is progressive. Research by Gong et al. (2024) shows that cumulative noise exposure can cause a gradual decline in hearing function that may not be detected in simple subjective examinations.^{8,15} Other studies show that steady-state noise exposure causes significant hearing loss after 4–5 years, with a progressive pattern in the early years. A longitudinal study of manufacturing workers during the 2017–2020 period revealed a measurable pattern of increased risk.¹⁶

It should be noted that the assessment of hearing loss in this study was subjective. Objective audiometric examinations may reveal a higher prevalence, given that noise-induced hearing loss is progressive and the early stages are often unnoticed.^{15,16}

The absence of sleep disturbances (100%) contrasts with findings at international airports. This difference can be explained by the absence of nighttime flight operations at Tampa Padang Airport. Münzel et al. (2020) showed that nighttime aircraft noise is the strongest predictor of sleep disturbance.¹⁷ These findings imply the importance of maintaining night flight restriction policies.

The absence of reported psychological stress can be explained by habituation. The average length of stay of 10-12 years provides sufficient time for psychological adaptation.¹⁸ However, subjective habituation does not guarantee physiological habituation. Schmidt et al. (2015) found that physiological responses (increased blood pressure, sympathetic nervous system activation) still

occurred even though subjects reported being accustomed to the noise.¹⁹

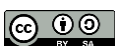
The possibility of reporting bias should be considered. The use of interviews to assess sleep disturbances has limitations compared to objective measurements such as actigraphy. In addition, social desirability bias may lead to underreporting of complaints.

This study has several limitations: (1) the cross-sectional design cannot capture long-term changes; (2) only three measurement points; (3) health assessment is self-reported without clinical validation; (4) no control for confounding variables such as occupational noise exposure; and (5) the possibility of reporting bias.

CONCLUSIONS AND SUGGESTIONS

Based on the research objectives, it can be concluded that aircraft noise levels around Tampa Padang Airport range from 64.5 to 92.1 dB, all of which exceed Indonesian (55 dB) and WHO (45 dB Lden) quality standards. The landing phase produces higher noise levels than take-off. The identified health impacts include hearing impairment in 17.1% of respondents (16% mild, 1.1% moderate). No sleep disturbances or psychological stress were found. The low prevalence of health impacts is likely due to the absence of night flights and psychological habituation due to long-term residence.

Based on the conclusions of the research results, there are several recommendations in this study, namely the establishment of noise contours based on comprehensive measurements for spatial planning regulations, the implementation of the



Continuous Descent Approach (CDA) procedure to reduce landing noise, and a longitudinal study with a cohort design to assess long-term health impacts.

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CONFLICT OF INTEREST

The authors declare that all data and information presented in this paper have no conflict of interest with any party. This research was conducted independently without any personal, institutional, or sponsor influence or interest that could affect the results of the research.

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