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Original Research

Virtual Reality for Assessing Willingness to Accept Compensation: An Exploratory Study of New Airport Noise Impact in Chiang Mai, Thailand

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Abstract: This exploratory study investigated virtual reality (VR) as a potentially more efficient tool for willingness to accept (WTA) compensation assessment in Thailand since conventional contingent valuation methods (CVM) could be limited in assessing WTA for aircraft noise, which is vital, especially in the context of airport development. A comparison study (n=140) near a proposed new airport in Chiang Mai divided participants into VR and non-VR groups. Using a linear mixed model, the VR group's total WTA was significantly higher; the variance varied with noise intensity. Furthermore, VR's impact on WTA interacted significantly with gender, age, and educational level. Among the main drawbacks were the VR device's efficiency, a noise model from an actual airport, and not evaluating prior VR experience or any adverse effects related to VR. Future research should take these elements into account, investigate different VR configurations, and examine more general environmental influences for more complete policy creation.

1. Introduction

Although a major engine of the world's economic expansion, airport construction always results in environmental effects; aircraft noise is a main issue for surrounding people. The growing demand for air travel calls for both the building of new airports and the expansion of current ones, therefore stressing the necessity of efficient noise reducing techniques. Like many other nations, Thailand struggles with this; educated regional planning and policy development depend on research on the effects of airport noise and the value of these consequences. Three main components form this introduction: Studies on noise valuation; VR in environmental valuation; socioeconomic influences on WTA.[TK1]

1.1 Noise Valuation Studies

Hedonic pricing models and stated preference methods are the two primary approaches that are utilized in order to accurately evaluate the impact that noise effects have on the economy. For the purpose of determining the cost of noise, a method known as hedonic pricing can be utilized. This method involves analyzing the connection between the levels of noise and the values of the properties.

Many studies' findings point to a statistically significant inverse relationship between noise levels and property values (for example, Friedt & Cohen 2019 found that noise abatement has effects; Winke 2017 found that prices devalued when a new runway opened). Poll results show that people living in houses in the Louder area are ready to pay less on their homes.

On the other hand, although without certain drawbacks, hedonic pricing theories could be useful tools. Changes in the market, for example, can call for some time until a new equilibrium is set. Almer et al. (2017) found this by underlining that after a change in flying restrictions, rentals in the neighborhood of an airport required approximately two years to normalize. By means of hedonic valuations, this data emphasizes the need of considering times of non-equilibrium. Schipper et al. (2001) found this while looking at how airplane noise affected home rents. They found that varying levels of noise produced similar impacts on the costs of residential rentals. Their study outcomes were as follows.

Alternatively, stated preference methods—which include instruments including the Contingent Valuation Method (CVM) and Choice Experiments—are used to directly elicit people's willingness to pay (WTP) or willingness to accept (WTA), therefore eliminating or compensating for noise effects. Research conducted in Thailand has shown WTA-related data in relation to airport noise. Chalermpong & Klaiklueng (2011) investigated university faculty personnel' WTA close to Suvarnabhumi Airport. The research revealed mean WTA values and the effect of noise variations. Their follow-up study, Chalermpong & Klaiklueng (2012) used a Choice Experiment to gauge the WTA connected with increasing aircraft operations for renters near the same airport. Kotchompoo (2022) examined the WTA of residents close to Chiang Mai International Airport. The results of the study highlighted the considerable degree of noise effect as a main cause and revealed a great diversity of WTA values. In a research conducted close to a growing airport, Miyakawa et al. (2010) applied CVM to evaluate the economic disutility of sleep disruptions brought on by both road traffic noise and airplanes. Their results showed variation in the disutility based on disturbance frequency. [TK2]

Given all of this study, it indicates that a vast variety of variables and the setting in which WTA values are applied influence them. These elements are personal and socioeconomic characteristics, the type of noise effect, and the particular group impacted. It is also important to emphasize, given that stated preference techniques can directly evaluate the value of intangible benefits, that these methods are vulnerable to hypothetical bias, which suggests that respondents may not represent their actual preferences.

1.2 VR on Environment Valuation

Virtual reality (VR) has evolved into an intriguing tool to manage some natural limits related to conventional environmental assessment methods. By providing users with immersive and realistic simulations of environmental situations, VR holds enormous promise for increasing the accuracy and robustness of environmental evaluations. By creating a VR toolchain capable of mimicking airplane noise under several operational processes and weather conditions, Arntzen et al. (2011) revealed this promise.

This feature specifies noise interference. By asserting that training conducted on VR systems generated more knowledge acquisition and retention than traditional approaches in aircraft flying and maintenance situations, Ziakkas et al. (2023) underlined even more the application of VR in training and educational contexts. Given its awareness of the major influence of contextual factors on noise perception, VR provides a powerful tool for changing these variables. Dedieu et al. (2021) demonstrated VR's capacity to isolate and change environmental factors by means of research on how geography influenced the subjective pleasantness of simulated flyovers. Building on this effort, Using visual and audio occlusion by buildings, Aalmoes et al. (2019) produced auralization of a VTOL aircraft inside an urban area, hence significantly enhancing the realism of the simulation inside an Oculus Rift VR environment. This method corrects shortcomings in earlier auralization algorithms that occasionally overlooked urban ambient complexity. Sahai et al. (2012), comparable to this, developed a VR air traffic simulation with auralization and three-dimensional visualization to provide a more subjective assessment of noise impact, therefore acknowledging the limitations of relying just on numerical noise measures.

Aalmoes & Sieben (2021) used a Virtual Reality experiment to evaluate human perception and noise annoyance linked with drones and Personal Air Vehicles (PAVs) in an Urban Air Mobility (UAM) setting, addressing the changing noise concerns posed by novel aircraft types and comparing these impressions to those of more familiar sounds. Their trial considered people's personal noise sensitivity and included several audio-visual settings. Outside the sphere of noise evaluation, Lewis et al. (2016) investigated VR's ability to distract from discomfort-causing stimuli including noise inside a simulated aircraft cabin, hence implying possible uses to improve passenger comfort.

These studies taken together indicate that virtual environments significantly increase the accuracy of environmental valuation. Compared to traditional methods, VR's greater realism and immersive experience aid to make situations more realistic, hence reducing hypothetical bias and allowing dynamic, real-world exposure patterns. This immediately addresses several limitations inherent in conventional valuation methods.[TK3]

1.3 Socioeconomic influences on WTA

Many people agree that people's views on and reactions to environmental disamenities like noise are greatly shaped by their socioeconomic situation. Indeed, studies by Miyakawa et al. (2010) using contingent valuation technique found a statistically significant link between Willingness-To-Accept (WTA) for sleep disturbances and other socioeconomic factors. Their results especially underlined a pattern of rising WTA with age, a WTA gradient across socioeconomic levels (with white-collar and executive professionals reporting a higher WTA than blue-collar workers), and a positive correlation with people's self-reported noise sensitivity.

Research in Thailand, on the other hand, points to a more complex and context-dependent interaction of variables. While Kotchompoo (2022) noted a tendency for households in larger homes and those occupied by people aged 31 to 40 in the vicinity of Chiang Mai Airport to show higher WTA, other elements including higher income levels, living in detached homes, more geographical distance from the airport, and living in particular specific areas were found to be related with lower WTA. Especially, the higher perceived effect of the noise was a constant cause of rising WTA. Moreover, subjective views had a noticeable influence: those who believed in good economic effects tended to lower WTA; those who acknowledged the negative effects or disagreed with certain mitigation plans raised it.

Chalermpong & Klaiklueng (2011), in their study of university staff near Suvarnabhumi Airport, discovered that WTA was greatly affected by elements including employment status, years of service, monthly rental cost, and plans about moving as their findings matched expected directions. Interestingly, they also said that within their research population demographic characteristics like gender, age, marital status, and number of children did not seem to have a statistically significant effect.

Looking beyond the direct impact of perceived noise levels, the body of current studies emphasizes the complex and context-sensitive character of socioeconomic elements in forming WTA. The development of fair and efficient noise compensation rules depends on a thorough knowledge of these several interactions including personal attitudes and perceptions.

Relying on existing Contingent Valuation Method (CVM) frameworks to estimate the economic effects of airport noise may naturally limit respondents' ability to completely imagine practical situations using standard questionnaires. Although virtual reality (VR) has great potential for developing immersive simulations, its use in the field of Willingness-to-Accept (WTA) evaluation—especially in the local context of Thailand—remains a quite young area of study. This study attempts to fill this vacuum by particularly assessing the impact of VR on WTA ratings about airport noise in Thailand. The study will control a variety of relevant socioeconomic factors across a range of airport noise levels to allow a direct comparison of WTA values between participants responding via traditional questionnaires (the non-VR group) and those interacting with the immersive VR-based simulations (the VR group). The study will explicitly look at the WTA values stated by each group, explore how the difference in WTA changes as a function of noise level that is expected to occur at this airport, and carefully assess the interaction between important socioeconomic factors and exposure to VR in affecting expressed WTA.

The expected outcomes are:

- Higher WTA values in the VR group compared to the non-VR group.
- A varying difference in WTA between groups across noise levels.
- An interaction between socioeconomic factors and VR exposure influencing WTA.[TK4]

These expectations stem from the deeply engaging nature of VR, a feature we anticipate could lead to a more accurate understanding of how unpleasant noise truly is for individuals. With a clear aim to contribute to environmental impact assessments that reflect reality more closely, to help shape noise control plans that are fair and effective for everyone, and to ensure that both social and environmental costs are factored into our pursuit of sustainable development, this study offers an initial glimpse into whether VR could be a viable tool for assessing WTA within Thailand. Our hope is that this work will serve as a valuable starting point for future research efforts in this important field.

2. MATERIALS AND METHODS

This exploratory study investigates the feasibility and potential of Virtual Reality (VR) technology in evaluating Willingness to Accept (WTA) compensation for operational aircraft noise from a planned new airport in Chiang Mai province, Thailand using a quantitative research method with an experimental design. Particularly in Chiang Mai, a key centre for tourist, business, and culture in Northern Thailand, this paper investigates the consequences of operational aircraft noise in the proximity of the airport, a vital element in development planning. Currently, the main entry point for both domestic and foreign travel is Chiang Mai International Airport (CNX). Plans are in the works to build a second airport, Lanna. Lanna Airport's site is expected to be around 22 kilometers from Chiang Mai International Airport between San Kamphaeng district in Chiang Mai and Ban Thi district in Lamphun (Thansettakij 2024). Proposed sites of Lanna Airport (Chiang Mai Airport 2) and Existing Chiang Mai Airport are shown in Fig. 1.

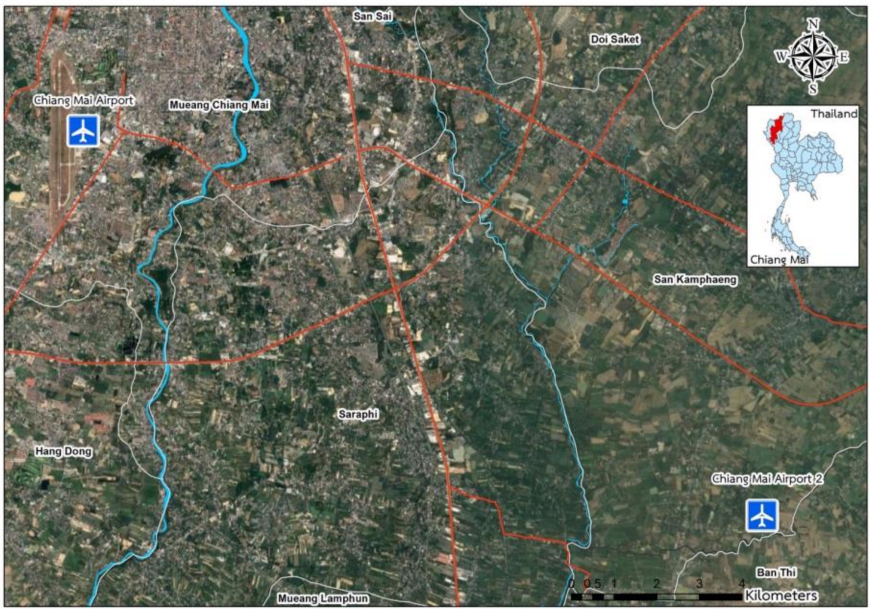

Fig. 1: Location of Chiang Mai Airport and Proposed Chiang Mai Airport 2

Since Lanna Airport is still in the planning stages, it is difficult to look into how WTA would be affected. Traditional techniques relying on hypothetical situations and surveys, such as the Contingent Valuation Method (CVM), have the possibility to produce inaccurate findings. Virtual reality technology is a creative substitute that can increase the precision of the WTA evaluation. This study contrasts and compares the experimental group, which assesses WTA with virtual reality simulations of aircraft noise, with the control group, which measures WTA with conventional CVM questionnaires and hypothetical situations. The experimental group assesses WTA using VR simulations of aircraft noise. Estimates (displayed on the right side of Figure 2) indicate that the study area covers the suggested site of Lanna Airport, which falls inside the NEF 30-40 zone. This suggests that compensation policies need to be established.

Lanna Airport is still under design; hence the simulation of airplane noise uses the most recent CNX airport data (Fig. 2, left). The VR technique's validity in assessing the value of Lanna Airport is supported by noise data from Chiang Mai Airport (CNX), an airport expected to have operational characteristics and aircraft types similar to Lanna Airport. Once operational, Lanna Airport is expected to alleviate air traffic congestion from Chiang Mai Airport (CNX) with similar flight operations and aircraft types, suggesting potentially comparable noise impacts. Therefore, the CNX noise data offers a fair starting point for VR simulation. Given the exploratory research now in progress and the presently available data, this approach is appropriate. But achieving a good simulation that accurately reflects the real thing will call for more data and more preparation in the future.

Using high-resolution 360-degree cameras at Chiang Mai University, which is near CNX and sits within the NEF 30-40 zone, researchers recorded the real ambience noise inside residences. Among the many situations this set of recordings captured were those with sounds from takeoff and landing of planes. Audio calibration was done before deployment by merging film into a virtual reality simulation using 3D airplane models (jessyara 2024) calibrated for position, size, and motion to simulate real-world conditions. An exact sound level meter was used to guarantee that the noise levels produced by virtual reality were fair and accurate reflections of the conditions in the real world.

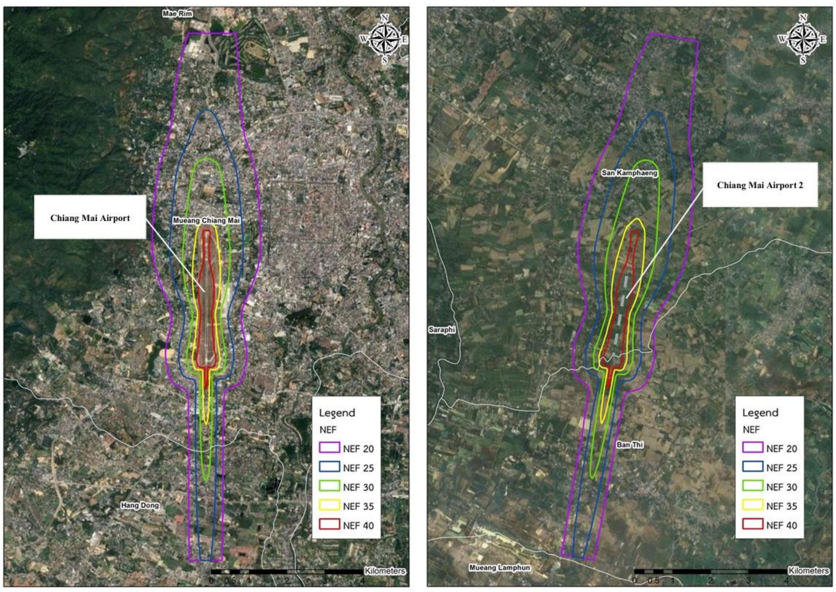

Fig. 2: NEF noise contour of Chiang Mai Airport (left) and Chiang Mai Airport 2 (right)

NEF 30–40 zone residents around CNX were assessed to validate the use and quality of the VR system. Using a questionnaire anchored on the VR-Check framework, three primary dimensions—immersion capacities, ecological relevance, and user feasibility—were assessed (Krohn et al. 2020). Additional divisions of these criteria were five subcategories: visual and aural realism, comparison to real-life occurrences, general scenario simulation capabilities, usability, and physical comfort. Participants rated every component using a five-point Likert scale: 1 = extremely low to 5 = very high and provided additional remarks. The results showed sufficient efficiency with an overall average score of 4.41 out of 5.00.

Participants for the VR compensation valuation came from nearby residents of the proposed Lanna Airport. The sample size was determined by combining the non-parametric statistical method suitable for comparing two independent groups, the Wilcoxon-Mann-Whitney test, with the G*Power Analysis tool.

Cohen's criteria were used to perform a two-tailed test with an equal allocation ratio (N2/N1 = 1), a significance level (α) of 0.05, a statistical power (1-β) of 0.80, and an effect size (d) of 0.5. The sample size was raised from the initial estimate of 67 individuals in each category (134 total) to 140.

Although general knowledge of the proposed Lanna Airport construction was strong in the community, the particular context of the study and the possibility of aircraft noise effects were clearly addressed to all participants during the informed consent procedure, hence addressing any possible selection bias. This guaranteed that individuals were clearly aware of the hypothetical scenario when they made their WTA judgments. [TK5]

The survey had three parts: WTA assessment, basic demographic and socioeconomic data, and participants' reflections and comments. Based on Airports of Thailand Public Company Limited (2022) data, the WTA assessment's experimental group underwent a virtual reality simulation of airplane noise at LAmax levels of 40, 60, and 80 dB(A); the control group got scenario descriptions and other information. Selected to demonstrate a spectrum of noise exposure, these figures show: 40 dB(A) is the threshold at which effects begin; 60 dB(A) is comparable to the documented LAeq 24-hour values; and 80 dB(A) demonstrates the most expected effect but is still within allowed exposure limits. Beginning with one thousand Thai Baht (Kotchompoo 2022), the WTA question used a double-bounded dichotomous choice approach with extra choices depending on the first response. The reliability of the questionnaire was demonstrated by the Cronbach's alpha coefficient, which had a value of 0.88 over the permissible limit of 0.7 (Nunnally 1978).

A Linear Mixed Model adequately evaluated the WTA data, which had a great number of observations spanning a wide spectrum of noise levels. Jiang & Nguyen (2021) shows that this approach is rather appropriate for data suggesting correlations, especially in settings like ours, where repeated observations are gathered from the same people under many different environmental conditions. Adding the within-subject correlations produced by these ongoing noise level assessments allows this approach to increase the accuracy of the causal inferences obtained on the influence VR treatment has on WTA. Reaching this goal calls for consideration on both personal variety and complicating elements. VR was the treatment group's main independent variable compared to the control group.

This study has received ethical approval from the Research Ethics Committee at Chiang Mai University, under certification number 074/67. By providing thorough justifications about the research goals, anticipated advantages, data collecting techniques, possible hazards connected to VR device use, the right to consent or decline participation, the right to withdraw at any time, and the confidentiality of all collected data, the researchers protected the rights of the subjects. The results of the study are provided only in an aggregate form. To reduce any potential discomfort the researchers created a safe atmosphere for VR use, carefully tracked people, and limited exposure time.

3. RESULTS AND DISCUSSION

Using a Linear mixed model, this study examined the effects of virtual reality (VR) technology, different levels of simulated aircraft noise, and personal socioeconomic traits on Willingness to Accept (WTA) compensation for aircraft noise impacts from a proposed new Chiang Mai Airport. This approach allows us to statistically account for the impact of personal socioeconomic variables while isolating the specific impacts of VR and noise exposure. Comprising 140 people residing in the NEF 30-40 noise contour, the sample was appropriate for compensation. The socioeconomic profile of the sample is shown in Table 1.

Table 1: Socioeconomic Characteristics of the Sample Group

Socioeconomic Characteristics	Classes	n	%
Gender	Male	76	54%
	Female	64	46%
Age (years)	20-29	48	34%
	30-39	36	26%
	>39	56	40%
Marital Status	Not Married	54	39%
	Married	86	61%
Education Level	Up to Lower Secondary	63	45%
	Upper Secondary or Equivalent	26	19%
	Above Upper Secondary or Equivalent	51	36%
Income (THB)	< 10,001	32	23%
	10,001-15,000	34	24%
	> 15,000	74	53%

The sample group showed quite social variety. Slight majorities were married (61%) and male (54%). Those over 39 years old (40%) followed by 20-29 years old (34%), then 30-39 years old (26%) in order of the greatest age group. Regarding education, 36% had schooling above the upper secondary level whereas the biggest group, 45%, had a lower secondary school education or less. Most (53%) said their monthly income exceeded 15,000 THB. This variety guarantees that the analytical results more fully capture the demographic features of the affected region.

While a linear mixed-effects model provides parameter estimates for main effects, the presence of interaction terms between VR, noise level, and socioeconomic variables complicates their direct interpretation. Specifically, these main effect estimates represent conditional effects – the effect of one variable at a specific reference level of other interacting variables. This might not accurately reflect the overall effect of a factor across all levels of other variables. Therefore, Type III Tests of Fixed Effects were employed to assess the overall significance of each factor, by averaging over the levels of other factors in the model and accounting for the interactions.

After adjusting for all other factors in the model, the Type III Tests of Fixed Effects show in Table 2—show the relevance of each component (VR, noise level, and socioeconomic characteristics) on WTA.

Table 2: Overall Effects and Interactions (Type III Tests)

Effect	F Value	[1]p-value
Main Effect		
VR	60.6	<.0001***
Noise Level	107.11	<.0001***
Gender	1.22	0.2701
Age	7.79	0.0005 ***
Marital Status	0.57	0.4501
Education Level	8.52	0.0003 ***
Income	1.77	0.1718
Interaction Effect		
VR x Noise Level	3.03	0.0501*
VR x Gender	6.68	0.0103 **
VR x Age	10.51	<.0001 ***
VR x Marital Status	1.01	0.3161
VR x Education	17.05	<.0001 ***
VR x Income	0.28	0.7575

[1] significant: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

The analysis indicated extremely significant main effects for VR usage ($F = 60.60$, $p < 0.0001$), noise level ($F = 107.11$, $p < 0.0001$), age ($F = 7.79$, $p = 0.0005$), and education level ($F = 8.52$, $p = 0.0003$). Overall primary impacts were not shown by gender, marital status, or income. Notable interaction effects, however, were also seen (VR x Noise Level: $p = 0.0501$; VR x Gender: $p = 0.0103$; VR x Age: $p < 0.0001$; VR x Education: $p < 0.0001$), indicating that these variables shaped VR's impact on WTA.

A simple effects analysis was conducted to better understand these interaction effects and their direction, size, and specific group differences. Table 3 shows the simple effects of VR across all interaction factor levels together with estimated Cohen's d effect sizes to assess the practical significance of the observed differences. While Cohen's d, a standardized measure of effect size, shows the difference between two means in standard deviation units, β in this table displays the difference in Least Squares Means between the VR and Non-VR groups. Typically, a d of 0.2 is considered a small effect, 0.5 a medium effect, and 0.8 or above a large effect (Cohen, 1988).

Table 3: Simple Effects of VR (Differences of Least Squares Means)

Effect (of VR)	β	S.E.	t Value	[1] p-value	[2] effect size
Overall Comparison					
VR	623.70	80.12	7.78	<.0001***	2.03 (L)
Noise Level (L_{Amax} in dB(A))					
Low, 40 dB(A)	614.18	92.85	6.61	<.0001***	2.00 (L)
Medium, 60 dB(A)	728.46	92.85	7.85	<.0001***	2.37 (L)
High, 80 dB(A)	528.46	92.85	5.69	<.0001***	1.72 (L)
Socioeconomic Characteristics					
Gender					
Male	147.34	223.51	0.66	0.5103	0.48 (M)
Female	1100.06	175.65	6.26	<.0001***	3.58 (L)
Age (years)					
20-29	-58.11	219.48	-0.26	0.7914	-0.19 (S)
30-39	848.88	166.47	5.10	<.0001***	2.76 (L)
>39	1080.33	237.95	4.54	<.0001***	3.52 (L)
Marital Status					
Not Married	699.35	113.78	6.15	<.0001***	2.28 (L)
Married	548.06	106.01	5.17	<.0001***	1.78 (L)
Education Level					
Up to Lower Secondary	-30.16	123.23	-0.24	0.8068	-0.10 (S)
Upper Secondary or Equivalent	1108.64	158.12	7.01	<.0001***	3.61 (L)
Above Upper Secondary or Equivalent	792.62	130.97	6.05	<.0001***	2.58 (L)
Income (THB)					
<10,001	555.48	152.00	3.65	0.0003***	1.81 (L)
10,001-15,000	697.43	131.03	5.32	<.0001***	2.27 (L)
>15,000	618.19	104.35	5.92	<.0001***	2.01 (L)

[1] significant: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

[2] Effect Size (d): 0.2 (Small), 0.5 (Medium), 0.8 (Large)

The overall analysis revealed that VR significantly increased WTA (β = 623.70, $p < 0.0001$), with a large effect size (d = 2.03). This positive β value indicates that, on average, participants in the VR group had a WTA that was 623.70 Thai Baht higher than those in the non-VR group, demonstrating a substantial overall impact of VR exposure.

With Large effect sizes across the low (40 dB(A), d = 2.00), medium (60 dB(A), d = 2.37), and high (80 dB(A), d = 1.72) Noise conditions, further analysis looking at the basic impacts of VR at each noise level (LAmax in dB(A)) indicated notable increases in WTA at all levels (all p-values < 0.0001). The effect, nevertheless, was non-linear. The greatest impact occurred at 60 dB(A), which may be because at this level the loudness of the sound begins to be clearly and consistently perceived as disruptive, allowing VR to maximize the increase in this negative feeling. At 80 dB(A), which is already at a very loud level, the additional impact of VR may be reduced because the feeling of annoyance from the sound may have reached a saturation point. And at 40 dB(A), which is a quieter level, the effect of VR may also be less because the baseline noise is not yet sufficient to be clearly perceived as bothersome enough for VR to amplify the effect. Other factors such as the VR model, participant traits, and questionnaire design may also play a role, but this most certainly indicates a relationship between baseline noise and VR's improvement.

When focus on socioeconomic characteristics revealed some unexpected correlations between VR and WTA. Especially interesting was a gender disparity: women who were exposed to virtual reality (VR) showed a significant rise in WTA ($d = 3.58$, $p < 0.0001$). This result is diametrically opposed to the relatively small and statistically negligible impact seen in men ($d = 0.48$, $p = 0.5103$). Differences in how men and women feel emotions, process spatial information, or are more likely to suffer simulator sickness could help to explain this gap.

Age seems to have a major impact on VR responses as well. While younger adults (20-29) reported a modest, non-significant drop in WTA ($d = -0.19$, $p = 0.7914$), those in the 30-39 ($d = 2.76$, $p < 0.0001$) and over-39 ($d = 3.52$, $p < 0.0001$) age groups exhibited very considerable increases. From this one would infer that different life experiences, increased financial responsibilities and career demands, changing aspirations, or perhaps age-related changes in hearing sensitivity have a role. Moreover, although VR usually increased WTA for both married and single people, the impact appeared to be more pronounced for those not married ($d = 2.28$) in comparison to their married counterparts ($d = 1.78$), maybe indicating a higher sensitivity to disturbances in the home environment for those living alone.

There was a very clear link between WTA answers and degree of education. Those with at least an upper secondary level education reported significant gains in their WTA after VR exposure. On the other hand, those with lower secondary education had a little drop that was not statistically relevant ($d = -0.10$, $p = 0.8068$). Advanced education might enable individuals to handle the several facts shown in a VR environment, hence promoting a greater knowledge of the long-term consequences of noise pollution. Furthermore, a higher degree of education seems to be related to a greater awareness of environmental effects and a stronger capacity to picture future situations, which would then affect their readiness to accept particular circumstances.

VR revealed consistent significant rises in WTA across all income brackets despite the overall relationship with income not reaching statistical significance in our research, implying an impact across the economic spectrum. The immersive quality of virtual reality would suggest that it is especially good at increasing awareness of the effects of noise, maybe even offsetting the usual tendency for those with more money to be less sensitive to noise. Essentially, regardless of one's financial situation, the VR experience seems to provide a more immediate and felt feeling of possible disruption. The VR simulation may have given a shared experiential basis that, to some degree, normalized the perception of noise effect across different income levels, or maybe the emotional reaction triggered by the simulation was so intense to produce similar responses irrespective of financial situation.

The effect sizes offer useful information, despite the fact that not all interactions with socioeconomic characteristics achieved the level of statistical significance. A medium or high effect size may imply a real, although underpowered, influence even when a p-value is present that is more than the common statistical significance threshold (0.05). When it comes to evaluating data, this underlines how important it is to take into consideration both the statistical significance and the practical significance.

VR technology significantly increases aircraft noise Willingness-To-Accept (WTA) compared to traditional assessment methods. The greater WTA and the different WTA of the VR group across all noise levels confirmed our first Expected Outcomes. Demographically motivated, VR filed claims for compensation among college graduates, seniors, and women. This implies that VR could be a complicated and sensitive instrument for assessing environmental effects, hence allowing more equitable remedies.

Our method acknowledges certain reasonable technological limits, including the performance requirements of the VR equipment employed and the sound model's degree of accuracy. Moreover, we did not carry out a methodical evaluation of the adverse effects VR use might bring about, including discomfort. Given our primary focus on the specific problem of airplane noise, other relevant environmental impacts were not within the scope of our research. Importantly, the study did not gather information on people's prior knowledge of VR technology, a characteristic known to likely greatly influence their stated WTA. Considering a person's VR knowledge, it is only natural to assume that the simulated noisy setting will provoke different reactions. Future studies should seek to reduce these constraints by including evaluations of past VR experience and any reported discomfort, by investigating possible novelty effects connected with VR exposure, and by using qualitative research techniques to obtain a better knowledge of the underlying perceptions and experiences.

Our VR-based WTA evaluation offers exciting ideas for designing more just and comprehensive compensation schemes from a policy standpoint. Because VR affects declared WTA, legislators should consider using VR for immersive simulations of public consultation processes, especially among clear demographic groupings. This strategy may promote educated public debate and project support. This proactive and detailed study of environmental effects during project conceptualization may help lead development decisions toward more socially acceptable and sustainable results.

4. CONCLUSIONS

This exploratory study investigated the impact of virtual reality (VR) technology on willingness-to-accept (WTA) for aircraft noise from a proposed new airport in Chiang Mai Province. It was found that participants using VR tended to show significantly higher WTA values than the non-VR group both overall and at all three noise levels, which are the noise levels in the range expected for the new airport. These higher WTA values from VR were particularly pronounced among women, older individuals, and those with more education. This article points out that virtual reality (VR) truly helps in assessing WTA. However, the study did not include the people's prior virtual reality (VR) experiences, which might influence their reactions. Moreover, although a safe virtual reality environment and a technology verified for its usability were used, other sorts of virtual reality-related discomfort were not statistically investigated for the complete study.

To solve these limitations, future research should evaluate VR-related discomfort as well as past virtual reality experiences. Studying the influence of novelty effects and using qualitative methods to characterize the user subjectivity might assist in improving the validity of VR-based WTA assessments.

Ultimately, the inclusion of these changes might produce more consistent and dependable data that could support reasonable and efficient environmental laws and compensation schemes connected to airport noise and maybe other environmental changes with notable sensory characteristics.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, the International Conference on Harmonization in Good Clinical Practice (ICH-GCP), and The Belmont Report, and approved by the Chiang Mai University Research Ethics Committee (protocol code 074/67, 22 April 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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Conflicts of Interest: The authors declare no conflicts of interest.

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