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Urban Noise Pollution: Its Impact on Public Health in Legazpi and Davao City, Philippines

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Abstract

This study examines the levels of vehicular noise pollution and its associated health impacts in Davao City and Legazpi City, two urban areas in the Philippines with varying degrees of urbanization and traffic congestion. Using a comparative cross-sectional approach, noise levels were measured at key locations. Findings of the study showed that the Noise Exposure Patterns in Legazpi City revealed that fifty percent (50%) of the respondents has experienced noise often as against Davao City with only 44%. The all-day noise exposure is more prominent in Davao City about 50% of its respondents than the 30% in Legazpi City which implies a more pervasive noise environment. As to Noise Level Rating, forty percent (40%) of the respondents in Legazpi perceived the noise in their environment as moderate while Davao City has noted 40% results. Health Impacts were observed to be prevalent on the physical health due to sleep disturbances, affecting 30% both of the respondents in Legazpi City and Davao City. The anxiety was the leading issue of respondents mental health, affecting 40% of them, followed by stress about 30%, cognitive difficulties - 20%, and irritability which is 10%. These findings indicates that a substantial proportion of residents were exposed to disruptive noise wherein sleep disturbances and headaches are common in both study areas. Both Cities revealed that Environmental Noise Level particularly in the Central Business District has the highest daily average of 70 dB and 80db for Legazpi and Davao, respectively. The prominent age group of 31–45 years suggests a large portion of the workforce is actively engaged in the economy, likely working in both urban and industrial sectors. The employed individuals in Legazpi which is 20% compared to 12% in Davao, indicated a more diverse range of work environments, some of which has exposures to higher noise levels in construction, transportation, or small manufacturing businesses. The same is true to younger individuals with 25% of respondents falling between 18–30 years who has experienced higher levels of noise exposure, in terms of social activities, urban noise, and lifestyle habits, contributing to hearing impairment or other auditory disorders over time.

Keywords: *noise pollution, urban noise pollution, health impacts*

1. INTRODUCTION

1.1 Background of the Study

Noise pollution is a significant urban environmental issue, contributing to adverse health effects such as cardiovascular disease, hearing impairment, and psychological stress [5]. Vehicular noise is a significant source of urban noise pollution, particularly in rapidly growing cities. It originates from various traffic-related activities, including engine noise, tire friction, honking, and road surface interactions [3].

In urban settings like Davao City, a major industrial center, and Legazpi City, a smaller yet developing urban area, the increase in traffic volume has intensified noise pollution, leading to a range of public health concerns. Chronic exposure to traffic noise is associated with adverse health effects, including hearing loss, sleep disturbances, cardiovascular diseases, and psychological issues such as stress and anxiety[1] [6].

Davao City, one of Mindanao's largest urban hubs, has experienced significant economic and urban development. As of 2024, its population is approximately 2 million, spread over a vast area of 244,000 hectares, making it one of the largest cities globally in terms of land area. The city's economic strength is highlighted by its contribution of 51.8% to the Davao Region's Gross Regional Domestic Product (GRDP) and its service industry, which includes business process outsourcing (BPO), hospitality, and retail sectors [2] [9]. This leads to increased vehicular traffic and congestion in several areas in the city, which include Matina McArthur Highway, Buhangin Diversion Road near Davao International Airport, Tibungco Public Market, Sasa Wharf, and Bunawan Highway. Constant traffic flow exposes residents living near these areas to high noise throughout the day.

For instance, heavy traffic congestion along major routes in Davao has been reported, particularly during peak hours, such as on the Buhangin Diversion Road and Matina Crossing. Residents commuting through these areas frequently experience delays of up to two hours due to traffic, leading to daily stress and challenges in maintaining productivity [7] [4]. Furthermore, efforts like the Davao Public Transport Modernization Project aim to address congestion by improving public

transportation infrastructure, though its full implementation is still pending [7].

Moreover, The city's expansion as a commercial and industrial hub has worsened the noise pollution problem, especially with a mix of private vehicles, public transportation, and heavy trucks navigating these key roads [11]. The concentration of traffic in high-density areas exacerbates noise pollution, which shows the need for sustainable urban planning and transportation solutions.

Legazpi City, the capital of Albay in the Bicol Region, is smaller but has been undergoing significant urban development due to its role as a regional economic center and tourism destination. As of the 2020 census, Legazpi City has a population of 209,533, with a land area of 161.61 square kilometers, giving it a population density of approximately 1,297 people per square kilometer [8] [13]. In recent years, it has consistently ranked highly in the National Competitiveness Council's Cities and Municipalities Competitive Index, achieving the top spot in infrastructure development and economic dynamism in 2020, along with being ranked the second most competitive city in the Philippines under its category [10].

Known for its proximity to the iconic Mount Mayon, Legazpi City attracts both tourists and business activities, resulting in increasing traffic, particularly around its Central Business District, Public Market, and Boulevard. Additionally, Legazpi serves as a transport hub, connecting various parts of the Bicol Region through bus terminals and the local seaport, contributing to the city's traffic noise pollution. Although smaller than Davao City, Legazpi is beginning to experience the same public health concerns related to noise pollution as traffic congestion increases in tandem with its development.

Studies have shown that noise pollution not only poses environmental challenges but also disproportionately affects vulnerable communities living near busy roads [11]. Understanding how these urbanization patterns impact public health in both cities is important for developing noise mitigation strategies.

1.2 Objectives

This study was conducted to determine urban noise pollution and its impact on public health in Davao City and Legazpi City, Philippines. Specifically, it sought to a.) measure and compare the levels of noise pollution in Legazpi City and Davao City, focusing on key traffic-congested areas; b.) evaluate the physical health impacts of noise, including hearing loss, increased blood pressure, and sleep disorders ; c.) assess the mental health impacts of prolonged exposure to noise, such as stress, anxiety, and cognitive difficulties; d.) determine the effectiveness of current noise mitigation strategies aimed at reducing vehicular noise in both cities; e.) find out the biggest contributor to noise in these busiest areas of both cities; f.) propose new strategies for reducing vehicular noise pollution, including urban planning measures and policies aimed at traffic management; and g.) recommend solutions on how to reduce, alter, or minimize noise sources.

Moreover, this research has explored the following problems such as 1.) How do vehicular noise pollution levels and their health impacts differ between Davao City and Legazpi City?; and 2.) Are existing noise mitigation measures effective in reducing health risks in both urban settings?

The following hypotheses were tested namely: H1.) Urban noise pollution levels are significantly higher in Davao City compared to Legazpi City due to greater traffic congestion and vehicle density; H2.) Chronic exposure to noise pollution in both cities have significant negative effects on physical health; H3.) Residents in Davao City report higher levels of stress and anxiety due to increased exposure to noise compared to residents in Legazpi City; H4.) Current noise mitigation measures are insufficient to protect public health in both cities, with more pronounced inadequacies in Davao City; H5.) Implementation of additional noise reduction strategies significantly decrease noise pollution and its health impacts in both cities; and H6.) Type of vehicle, mufflers, wheels, horns, and engine noise varies as the main contributors of vehicular noise in the busiest areas of the City.

2. METHODOLOGY

2.1 Study Locale and Respondents

The study was conducted in two cities with contrasting levels of urbanization: Legazpi City and Davao City. Legazpi City is a medium-sized urban center in Albay, with a population of approximately 209,533 and an area of 161.61 square kilometers while Davao City is one of the largest and most urbanized cities in Mindanao, with a population of about 1.77 million and a land area of 2,443.61 square kilometers.

The study targeted a total of approximately 150 respondents, with 100 respondents from Davao City and 50 from Legazpi City. This distribution accounts for Davao's larger size and higher population density, which necessitates a larger sample for adequate representation. Respondents were selected from various socioeconomic groups: a.) Residents living near high-traffic areas and busy roads; b.) Workers employed in noisy environments such as markets, construction sites, or commercial areas; and c.) Vulnerable Groups including elderly individuals and children, who may be more sensitive to noise pollution.

In determining the number of respondents for each city, the calculation was based on the relative population size between the two cities using the formula below;

$$Proportion\ of\ respondents\ from\ Davao\ City\ = \frac{Population\ of\ Davao\ City}{Total\ Population\ of\ Both\ Cities} \qquad (1)$$
$$= \frac{1\ 776\ 949}{1776949\ +\ 209\ 533} = 0.89$$

Thus, approximately 89% of the total sample was allocated to Davao City, which amounts to:

$$0.89\ x\ 150\ =\ 133.5\ \approx\ 100\ respondents\ (Davao) \qquad (2)$$

The remaining respondents (approximately 11%) were allocated to Legazpi City, which amounts to approximately 15 respondents.

2.2 Research Design and Data Collection

This study used quantitative and qualitative research using self made survey questionnaires and interviews as it has involved in describing, analyzing and interpreting the existing conditions of the urban cities in terms of noise pollution and public health impacts and to extract relevant information from the respondents in the two (2) highly urbanized Cities in the Philippines.

In the data gathering for the study, it has considered some important aspects such as the noise pollution measurement which includes equipments, sampling points, and duration. Likewise, health impact assessment was also taken consideration using structured surveys and interviews.

2.2.1 Noise Pollution Measurement

Equipment. To measure noise pollution levels in the study areas, portable noise level meters are used. These devices measure sound levels in decibels (dB) which is a standard unit of measurement for noise following the guidelines set by the World Health Organization (WHO, 2018). The meters are calibrated to ensure accurate readings and regularly tested for reliability during the data collection period.

Sampling Points. Five key locations are selected in each city based on traffic density and the presence of noise pollution sources, ensuring that the sites cover a variety of urban environments. These sampling points are selected to represent areas with high traffic flow, significant economic activity, and residential zones, which are likely to experience elevated noise levels due to urbanization.

For Davao City, the key locations are the Central Business District, Matina Crossing, Sasa Wharf, Davao International Airport; and e.) Residential neighborhoods. On the other hand, Legazpi City covered key locations such as its Central Business District, Public Market, Bus Terminal, Boulevard; and e.) Residential neighborhoods

Duration. Noise measurements were taken for a month, capturing noise levels at different times of the day, particularly, in the morning, afternoon, and evening in order to account for temporal variations in sound levels due to traffic and other environmental factors.

2.2.2 Health Impact Assessment

Structured surveys were administered to respondents to assess their exposure to noise and its effects on their physical and mental health. The surveys were designed to evaluate key health indicators in both physical and mental health domains. It has also considered the physical health indicators to include the hearing loss (e.g., ringing in the ears, difficulty hearing in noisy environments), sleep quality (measured through questions about sleep disturbances, difficulty falling asleep, and waking up tired), headaches (frequency and intensity), and cardiovascular symptoms (e.g., elevated blood pressure, chest pain, or heart palpitations). Finally, the mental health indicators include stress levels (perceived daily stress and coping), anxiety (questions about the frequency of feeling nervous, worried, or tense), and cognitive function (e.g., focus, memory).

Interviews. In addition to the quantitative data collected from the surveys, qualitative interviews were also conducted with a selected group of respondents to provide deeper insights into their personal experiences with noise pollution. The interviews adopted the semi-structured form to allow flexible conversations on key topics. It has explored the perceived impact of noise pollution on the respondents daily lives, including emotional and social experiences, the adaptive strategies individuals employed to cope with or mitigate the effects of noise, and its perceptions of the sources of noise in their environments and how they believed it affected their health and well-being.

2.3 Data analysis

2.3.1 Quantitative Analysis

Descriptive Statistics. The noise level data were subjected to descriptive statistical analysis to summarize key aspects of the data. Averages (mean), ranges, and classifications based on location types (e.g., residential, commercial, industrial) and times of day (morning, afternoon, evening) were computed. These descriptive statistics provided a clear overview of the variation in noise levels across the sampled sites in both cities. This step identified patterns in the noise data, including peak periods of noise exposure and high-traffic areas contributing most significantly to pollution.

Comparison with WHO Noise Guidelines. The severity of noise pollution in the studied cities, noise levels were computed and compared to the World Health Organization's (WHO) guidelines on environmental noise. WHO has recommended a daily average of 53 dB for daytime and 45 dB for nighttime to minimize health risks (WHO, 2018). By comparing the measured noise levels to these standards, it is possible to evaluate whether the noise in both cities exceeded acceptable thresholds, which had been shown to contribute to cardiovascular diseases, hearing impairment, and mental health issues.

2.3.2 Qualitative Analysis

Thematic Analysis. Interview responses from selected respondents were transcribed verbatim and subjected to thematic analysis. This method involved coding the data to identify recurring patterns and themes related to the perceived health impacts of noise exposure, coping strategies, and residents' awareness of the problem. Thematic analysis allowed for an in-depth understanding of how individuals experienced noise pollution and managed its effects in urban environments.

Case Studies. This has developed to provide a more detailed exploration of individual experiences with noise pollution with greater focus on respondents who reported significant health impacts or who had unique coping strategies. The use of case studies allowed for a richer, more context-specific understanding of how noise affected different groups in the population and provided concrete examples of real-world challenges faced by residents in both Davao and Legazpi cities.

2.3.3 Comparative Analysis

Noise Level Comparison. A comparative analysis of the noise levels between the two cities was performed to identify factors that contributed to variations in vehicular noise pollution. Differences in urbanization, traffic density, road infrastructure, and industrial activities were noted to understand their role in the observed disparities between Davao City and Legazpi City.

Health Impact Comparison. Health impacts reported by respondents from each city were compared to assess the significance of noise exposure in different urban contexts. The analysis examined whether residents in high-traffic areas in Davao City reported more severe health issues compared to those in Legazpi, where urbanization was relatively less intense. This comparison helped determine whether higher noise levels were associated with worse health outcomes.

Mitigation Strategies. The effectiveness of existing noise reduction strategies in both cities was assessed. This analysis involved reviewing public policies, urban planning initiatives, and individual coping mechanisms aimed at reducing noise exposure. The effectiveness of soundproofing measures, traffic management strategies, and public awareness campaigns was evaluated based on the feedback from respondents and the recorded noise levels.

2.4 Validation of Findings

An expert review was conducted to ensure the reliability and validity of the findings especially on the noise measurement protocols and health assessment tools used. Whereas, environmental scientists, noise pollution experts, and public health professionals had evaluated the methodologies, ensuring that the instruments for measuring noise levels (such as portable sound level meters) and the health surveys are accurate and reliable. The validation has also included the assessment and the comprehensiveness of the health indicators, to reflect the full spectrum of potential physical and mental health effects related to noise exposure. Expert feedback refined the tools, making it contextually relevant and scientifically sound.

3. RESULTS AND DISCUSSIONS

3.1 Demographic profile

The demographic profile of the respondents in Legazpi City and Davao City were gathered in order to gather context in terms of the socioeconomic dynamics that could influence noise exposure patterns.

The results of the survey in terms of the demographic profile of the respondents in Legazpi City are shown in Table 1.

Table 1: Legazpi City Respondents Demographics

Demographic Factors	Respondents	Frequency (%)
Age	Under 18	10
	18 - 30	25
	31 - 45	40
	46 - 60	15
	Above 60	10
Gender	Male	45
	Female	55
Employment Status	Employed	60
	Self-employed	20
	Unemployed	10
	Retired	10

The demographic profile of Legazpi City reveals that the largest age group among respondents is 31–45 years old, comprising 40% of the population. This suggests that a significant proportion of the surveyed individuals are in their prime working years, contributing to the labor force and economic activity in the city. Notably, 25% fall within the 18–30 age range, indicating a relatively young population. The representation of respondents under 18 and above 60 is smaller, at 10% each, which shows a balanced age distribution with a focus on the economically active middle-aged group.

The gender distribution in Legazpi City is nearly balanced, with 55% female and 45% male respondents, which shows a slight majority of women in the surveyed population.

Regarding employment status, 60% of respondents are employed, and an additional 20% are self-employed, suggesting that 80% of the population is actively participating in economic activities. Unemployment and retirement rates are both at 10%, indicating a relatively stable employment landscape with a smaller proportion of non-working individuals.

On the other hand, the results of the survey in terms of the demographic profile of the respondents in Davao City are shown in Table 2.

Table 2: Davao City Respondents Demographics

Demographic Factor	Respondents	Frequency (%)
Age	Under 18	8
	18 - 30	20
	31 - 45	47
	46 - 60	18
	Above 60	7
Gender	Male	47
	Female	53
Employment Status	Employed	62
	Self-employed	12
	Unemployed	19
	Retired	7

The demographic composition in Davao City shows a similar trend in the prominence of the 31–45 age group, which constitutes 47% of respondents. This indicates a predominantly middle-aged population actively contributing to the city's workforce. The younger group (18–30 years) accounts for 20%, while those under 18 and above 60 make up smaller portions, at 8% and 7%, respectively. This distribution shows a slightly more mature population compared to Legazpi City.

In terms of gender, the distribution in Davao City is comparable to Legazpi, with 53% female and 47% male respondents.

Employment status data revealed that 62% of respondents are employed, slightly higher than Legazpi's 60%. However, self-employment is less common in Davao (12% vs. 20% in Legazpi), and the unemployment rate is notably higher at 19%. This may indicate a more competitive job market or economic challenges in Davao. The retirement rate is lower at 7%, reflecting a smaller proportion of elderly respondents or retirees in the surveyed group.

Both cities exhibited a strong representation of economically active individuals aged 31–45, forming the backbone of their respective labor forces. However, Davao City has a slightly higher percentage of employed respondents, despite facing a higher unemployment rate. Gender distributions are nearly equal in both cities, suggesting equitable representation in the surveyed population.

The differences in self-employment rates (20% in Legazpi vs. 12% in Davao) may reflect variations in local economic structures, such as greater opportunities for small businesses or entrepreneurship in Legazpi. On the other hand, the higher unemployment rate in Davao warrants attention and may require targeted economic interventions to enhance job opportunities.

In Legazpi City, the prominent age group of 31–45 years suggests a large portion of the workforce is actively engaged in the economy, likely working in both urban and industrial sectors. This age group is particularly vulnerable to occupational noise exposure, which may have implications for long-term health effects such as hearing loss, cardiovascular diseases, and stress-related disorders. The higher proportion of self-employed individuals in Legazpi (20% compared to 12% in Davao) may indicate a more diverse range of work environments, some of which could involve exposure to higher noise levels in construction, transportation, or small manufacturing businesses. Given that the employment and self-employment rates are high, it can be assumed that many of these individuals spend a significant portion of their day in noise-prone environments, potentially leading to an increased risk of noise-induced health issues. Additionally, the relatively younger demographic in Legazpi (with 25% of respondents falling between 18–30 years) might experience higher levels of noise exposure, particularly in the context of social activities, urban noise, and lifestyle habits, contributing to hearing impairment or other auditory disorders over time.

In contrast, Davao City's demographic composition showed that the city has a slightly more mature population, with 47% of respondents falling within the 31–45 age group, which may reflect a more settled workforce. However, the higher unemployment rate (19%) in Davao compared to Legazpi suggests that a portion of the population may be facing economic

hardships or barriers to stable employment. This could lead to increased vulnerability to living in noisy, lower-income areas or informal settlements, where noise pollution from traffic, construction, or industrial activities could be more pronounced. Such environmental factors could exacerbate the physical and mental health impacts on individuals, especially those in lower socioeconomic groups. Moreover, the lower self-employment rate in Davao (12%) compared to Legazpi might indicate fewer opportunities for small business ventures, which could affect the noise exposure patterns. Davao's urban landscape may concentrate more individuals in larger formal or informal sectors, potentially exposing them to noise generated by mass transit systems, markets, and densely packed residential areas.

Both cities exhibited relatively balanced gender distributions, which suggests that noise exposure and its health impacts are likely affecting both men and women equally, without significant gender-based disparities. However, health implications, such as stress, sleep disturbances, and cardiovascular issues due to chronic noise exposure, could manifest differently based on gender, with women potentially experiencing greater susceptibility to stress-related health outcomes.

3.2 Noise Exposure Patterns

The noise exposure patterns in Legazpi City, as presented in Table 3, revealed that a significant proportion of respondents around fifty percent (50%) has experienced noise more often, while thirty percent 30% were reported being exposed to noise constantly. These figures suggest that 80% of the population is exposed to frequent or continuous noise, which may have implications for both physical and mental health. Meanwhile, 15% of respondents indicated occasional noise exposure, and only 5% reported rare exposure, highlighting that minimal noise disturbance is uncommon in the city.

The noise exposure patterns in Davao City exhibited a different distribution pattern compared to Legazpi City. The forty four (44%) percent of respondents reported often experiencing noise, while only 10% are exposed to it constantly. This indicates a slightly lower prevalence of continuous noise in Davao City compared to Legazpi City. Occasional noise exposure is more common in Davao, with 34% of respondents reporting this frequency, and 12% experiencing noise rarely, a higher percentage than in Legazpi City.

Table 3: Noise Exposure Patterns in Legazpi City and Davao City

Factor	Responses	Legazpi	Davao
		Frequency	
Noise Exposure Frequency	Rarely	5	12
	Occasionally	15	34
	Often	50	44
	Constantly	30	10
Highest Noise Time	Morning	20	10
	Afternoon	30	30
	Evening	20	10
	All day	30	50

Regarding the time of highest noise occurrence, Table 3 above shows that 30% of respondents experience noise throughout the entire day, indicating persistent noise pollution. Afternoon noise peaks at 30%, followed by equal reports of morning and evening noise at 20%. This distribution suggests that noise in Legazpi City is most prominent during the afternoon and extends into all-day exposure for a significant portion of residents.

On the other hand, 50% of respondents in Davao City have reported an all-day noise occurring, a significantly larger proportion compared to Legazpi City. Afternoon noise is the next most common, at 30%, while both morning and evening noise occur less frequently, at 10% each. These results suggest that noise pollution in Davao City is more concentrated throughout the entire day, with less variation during specific times.

The data demonstrated that both cities have experienced high levels of noise exposure, but with distinct patterns. In Legazpi City, noise is more likely to occur frequently or continuously, with 80% of respondents falling into these categories, compared to 54% in Davao City. Conversely, Davao City shows higher rates of occasional or rare noise exposure, reflecting a wider range of experiences among its residents. All-day noise exposure is more prominent in Davao City about 50% of its respondents than in Legazpi City about 30% only, suggesting a more pervasive noise environment in Davao. In both cities,

afternoons are consistently reported as the peak noise period, which shows a common trend likely linked to high vehicular or commercial activity during this time.

3.3 Noise Level Rating

The noise level ratings in Legazpi City, indicate that forty percent (40%) of the respondents perceived the noise in their environment as moderate while a significant portion of the population around thirty percent (30%) rated noise levels as high, and twenty percent (20%) had described it as very high which collectively accounted at least half of the respondents to experience considerable noise intensity. The remaining ten percent (10%) of respondents rated the noise level as low, suggesting that low noise levels are a minority experience in Legazpi City. These findings implies that a substantial proportion of residents are exposed to disruptive noise, with 50% reporting high or very high levels needing appropriate interventions to address the adverse effects associated with elevated noise levels in urban environments.

In Davao City on the other hand, presented a different results where forty percent (40%) of respondents reported a moderate noise levels. However, Davao City shows a higher proportion of respondents of 45% experiencing high noise levels, compared to 30% in Legazpi City. Conversely, only 5% of respondents in Davao City rated the noise level as very high, a lower percentage than in Legazpi City. As in Legazpi City, just 10% of respondents in Davao City reported low noise levels.

These results suggests that while moderate noise levels are prevalent, Davao City has a larger share of respondents exposed to high noise levels. This reflects the impact of the city's greater population density, vehicular traffic, and industrial activity, contributing to more intense noise environments. Please see table 4.

Table 4. Noise Level Rating in Legazpi City and Davao City

Responses	Legazpi	Davao
	Frequency	
Low	10	10
Moderate	40	40
High	30	45
Very High	20	5

The data from Table 4 above indicated that both cities experience similar patterns in moderate and low noise level ratings, with moderate noise being the most commonly reported level in both locations. However, the distribution of high and very high noise ratings highlights key differences such as Davao City has a greater proportion of high noise ratings of 45% but nevetheless, fewer very high ratings about 5% compared to Legazpi City with 30% and 20%, respectively.

The disparity noted reflected a differences in the nature and sources of noise pollution in the two cities. Davao City, being a larger urban area, likely has more widespread but varied noise sources, leading to higher overall noise levels without as many instances of extreme noise intensity. Conversely, Legazpi City may have localized sources of very high noise, possibly linked to specific activities or locations such as transportation hubs or commercial zones.

3.4 Health Impacts

The residents of Legazpi City reported significant physical and mental health impacts attributed to noise exposure. The most prevalent physical health issue was sleep disturbances, affecting 30% of the respondents. This finding aligns with the elevated noise levels during both daytime and nighttime in the city, as shown in prior sections. Headaches were reported by 25% of the respondents, while hearing loss impacted 15%, due to prolonged exposure to noise levels that exceeded the recommended thresholds. Cardiovascular symptoms, such as high blood pressure, were the least reported physical health impact at 10%, though they remain a concern due to the potential long-term risks associated with chronic noise exposure.

In terms of mental health, stress was the most commonly reported impact, affecting 40% of respondents, followed by anxiety

about 35%, irritability - 25%, and cognitive difficulties at 20%. The high prevalence of stress and anxiety shows the psychological toll of living in an environment with frequent and intense noise exposure.

The health impacts reported by respondents in Davao City reveal even greater concerns. Among physical health issues, sleep disturbances were the most frequent complaint, affecting 45% of respondents, which is notably higher than in Legazpi City. Similarly, headaches showed 35% and hearing loss at 20% of affected respondents were observed in Davao City. Cardiovascular symptoms were reported by 10% of respondents, comparable to Legazpi City, but the cumulative health burden suggested a more pervasive impact of noise pollution in Davao City. Please see table 5.

Table 5: Health Impacts in Legazpi City and Davao City

	Health Indicators	Legazpi	Davao
		Frequency	
Physical Health Impact	Hearing Loss	15	20
	Sleep Disturbances	30	45
	Headaches	25	35
	Cardiovascular Symptoms	10	10
Mental Health Impact	Stress	40	30
	Anxiety	35	40
	Irritability	25	10
	Cognitive Difficulties	20	20

The anxiety was the leading issue of respondents mental health, affecting 40% of them, followed by stress about 30%, cognitive difficulties - 20%, and irritability which is 10%. The relatively lower levels of stress and irritability in Davao City compared to Legazpi City may reflect differing coping mechanisms or urban dynamics. However, the higher prevalence of anxiety indicates that the chronic nature of noise exposure in Davao City takes a significant psychological toll. While sleep disturbances and headaches are common in both study areas, Davao City has exhibited a higher rates, due likely to its more intense and prolonged noise exposure. Hearing loss is also more prevalent in Davao City around 20% than in Legazpi City which is 15%, suggesting that higher decibel levels in Davao City are contributing to auditory health risks.

Moreover, the stress is more pronounced in Legazpi City around 40% of its respondents, while anxiety is higher in Davao City at 40%. This variation may reflect differences in the types of noise and their perceived impact on daily life. The lower rates of irritability and cognitive difficulties in Davao City might indicate variations in noise sources or resilience among residents.

3.5 Awareness and Perceptions

The study showed that seventy percent (70%) or at least majority of respondents in Legazpi City are unaware of existing noise mitigation measures. Only 30% of respondents indicated awareness, which shows a significant gap in public information and education regarding noise control strategies. Meanwhile, as to the perceived effectiveness of current measures, 50% of respondents has responded as "not effective," while 30% rated them as "slightly effective." Only a minority found these measures "moderately effective" and "very effective" at 15 and 5%, respectively. These perceptions is consistent with the persistent noise issues of respondents in terms of noise level and exposure, implying dissatisfaction with the efforts made to address noise pollution. However, 85% of respondents expressed support for stricter regulations to combat noise pollution, signaling strong public demand for more robust and effective policies. However, 10% opposed such measures, and 5% were unsure, suggesting a need for further community engagement and education on the benefits of stricter noise control.

The situation in Davao City shows an even starker picture regarding awareness where 92% of respondents reported being unaware of any existing noise mitigation measures, while only 8% indicated awareness. This lack of awareness suggests that current communication and outreach efforts are insufficient, if not lacking. In terms of effectiveness, 40% of respondents rated the measures as "not effective," with smaller percentages finding them "slightly effective" about 20% or "moderately effective" at 30%. Notably, no respondents rated current measures as "very effective." These results suggests that nothwithstanding the implementation of urban noise pollution measures, it may be possible that they are either poorly executed or inadequately enforced.

Support for stricter regulations in Davao City is high but slightly lower than in Legazpi City, with 73% of respondents in favor. Meanwhile, 27% opposed stricter regulations, with no undecided respondents, indicating a more polarized opinions compared to Legazpi City. Please see table 6.

Table 6. Awareness and Perception in Legazpi City and Davao City

	Responses	Legazpi	Davao
		Frequency	
Awareness of Mitigation Measures	Yes	30	8
	No	70	92
Effectiveness of Current Measures	Not effective	50	40
	Slightly effective	30	20
	Moderately effective	15	30
	Very effective	5	0
Support for Stricter Regulations	Yes	85	73
	No	10	27
	Not sure	5	0

Awareness of noise mitigation measures is significantly lower in Davao City around 8% than in Legazpi City which is 30%, suggesting that public awareness is slightly better in Legazpi. The situation could be either, due the lack of public involvement or less government interventions. However, in both cities, the majority of respondents are unaware of existing measures, showing a widespread issue of inadequate communication and public education.

Perceptions of effectiveness are slightly better in Davao City, where 30% of respondents rated measures as "moderately effective" compared to only 15% in Legazpi City. However, the lack of a "very effective" rating in Davao City and the very low percentage in Legazpi at 5% indicated a shared need for improvement in noise control measures.

Support for stricter regulations or measures was observed to be stronger in Legazpi City than in Davao City as shown by 85% and 73% responses of respondents, respectively. The difference may reflect varying levels of trust in the law enforcement or differences in the perceived severity of noise pollution.

3.6 Environmental Noise Level Analysis

The recorded noise levels in Legazpi City were measured across five locations: the Central Business District, Public Market, Bus Terminal, Boulevard, and Residential Neighborhood. These measurements were compared to the World Health Organization (WHO) safe noise standards for different times of the day (Morning, Afternoon, Evening) and averaged for daily levels. The results reveal varying degrees of compliance with the recommended limits, as shown in Table 7.

Table 7. Decibel (dB) Measurement Results in Legazpi City

	Morning (dB)		Afternoon		Evening		Average Daily	
Location	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**
Central Business District	67	70	73	75	70	70	70	70
Public Market	65	65	71	70	69	60	68	65
Bus Terminal	72	70	76	75	74	70	74	70
Boulevard	63	65	68	70	66	65	66	65
Residential Neighborhood	55	55	58	60	60	50	58	55
Average	**64.4**	**65**	**69.2**	**70**	**67.8**	**63**	**67.2**	**65**

The noise levels in the Central Business District (CBD) remained within the WHO safe standards across all time periods. The recorded values range from 67 dB in the morning to 73 dB in the afternoon, with an average daily level of 70 dB, all of which are below the corresponding WHO thresholds. This suggests that the CBD is managed well in terms of noise pollution despite the high commercial activity typically associated with such zones. However, noise levels during peak hours in the

afternoon approach the upper limits of the safe standard.

The Public Market experiences higher noise levels, particularly in the afternoon (71 dB) and evening (69 dB), both of which exceed the WHO safe standards of 70 dB and 60 dB, respectively. These elevated noise levels can be attributed to the busy trading activities, vehicular traffic, and pedestrian interactions that peak during these times. While the daily average of 68 dB slightly exceeds the WHO standard of 65 dB, it shows the need for interventions to mitigate noise pollution during operational hours.

The Bus Terminal consistently exhibited the highest noise levels among all locations. Noise levels recorded during the morning (72 dB), afternoon (76 dB), and evening (74 dB) all exceed the respective WHO standards of 70 dB and 75 dB. The daily average noise level of 74 dB also surpasses the recommended threshold of 70 dB. These results indicate significant noise pollution caused by heavy vehicular traffic, public announcements, and large crowds, particularly during the afternoon peak.

Noise levels along the Boulevard generally fall within acceptable limits, except for a slight exceedance during the evening (66 dB) compared to the WHO standard of 65 dB. The recorded morning (63 dB) and afternoon (68 dB) values remain below the respective safe limits. The daily average noise level of 66 dB aligns closely with the recommended threshold of 65 dB, suggesting that the Boulevard is relatively quieter compared to other commercial areas but still requires minor adjustments to reduce evening noise levels.

The Residential Neighborhood meets the WHO safe noise standards in the morning (55 dB) but slightly exceeds them during the afternoon (58 dB) and evening (60 dB), with the latter being 10 dB above the recommended limit of 50 dB. The daily average noise level of 58 dB also exceeds the standard of 55 dB, highlighting potential risks to residents, such as sleep disturbances and stress due to prolonged exposure to noise. This is particularly concerning in residential zones, where lower noise levels are crucial for health and well-being.

When averaged across all locations, the recorded noise levels for the Morning (64.4 dB), Afternoon (69.2 dB), and Evening (67.8 dB) show varying degrees of compliance with WHO standards of 65 dB, 70 dB, and 63 dB, respectively. The daily average across all locations is 67.2 dB, exceeding the WHO standard of 65 dB. These findings indicate that while morning noise levels are relatively close to safe limits, the afternoon and evening levels are higher, reflecting the impact of increased activity during these periods.

The results suggest that noise pollution in Legazpi City is primarily driven by high-traffic areas like the Bus Terminal and Public Market, where recorded levels consistently exceed safe limits. Residential neighborhoods, while quieter overall, still face elevated noise levels during the evening, which may pose health risks to residents. The Boulevard and CBD, although relatively compliant with standards, require monitoring and minor adjustments to maintain acceptable noise levels.

In contrast, Davao City displayed significantly higher noise levels across all locations, as shown in Table 8.

Table 8: Decibel (dB) Measurement Results in Davao City

	Morning (dB)		**Afternoon**		**Evening**		**Average Daily**	
Location	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**	**Recorded**	**WHO Safe Standard**
Matina Central Business District	77	70	82	75	80	55	80	70
Tibungco Public Market / Bunawan Highway	81	65	85	70	79	60	82	65
Davao International Airport	83	75	88	75	82	60	84	70
Sasa Wharf	81	70	84	70	81	60	82	65
Talomo Residential Neighborhood	76	55	78	55	70	45	75	55
Average	**79.6**	**67**	**83.4**	**69**	**78.4**	**56**	**80.6**	**65**

The recorded noise levels during the morning ranged from 76 dB at the Talomo Residential Neighborhood to 83 dB at the Davao International Airport, with an average of 79.6 dB across all locations. These values consistently exceeded the WHO safe standards, which range from 55 dB for residential areas to 75 dB for airports. Notably, the Davao International Airport exceeded its standard by 8 dB, reflecting significant noise pollution. Similarly, public areas such as the Tibungco Public Market and Sasa Wharf recorded levels of 81 dB, surpassing their respective thresholds by 16 dB and 11 dB, respectively. These findings reveal heightened noise activity even during the typically less congested morning period.

Noise levels peaked in the afternoon, with values ranging from 78 dB (Talomo Residential Neighborhood) to 88 dB (Davao International Airport). The city-wide average for the afternoon was 83.4 dB, markedly higher than the WHO safe average of 69 dB. The Davao International Airport again recorded the highest level, exceeding the standard by 13 dB, while other locations such as the Bunawan Highway (85 dB) and Sasa Wharf (84 dB) also exhibited substantial exceedances. The elevated afternoon noise levels can be attributed to increased vehicular traffic, business activities, and overall urban bustle during this time.

Evening measurements showed slight reductions in noise levels compared to the afternoon, with values ranging from 70 dB (Talomo Residential Neighborhood) to 82 dB (Davao International Airport). The average evening noise level was 78.4 dB, still significantly above the WHO safe average of 56 dB. Residential areas like Talomo were particularly affected, with recorded levels exceeding the safe threshold by 25 dB, posing potential risks to the health and well-being of residents. Commercial and transit hubs such as the Matina Central Business District and Sasa Wharf also continued to exhibit elevated noise levels, reflecting consistent exposure throughout the day.

The average daily noise levels for all locations ranged from 75 dB (Talomo Residential Neighborhood) to 84 dB (Davao International Airport), with an overall average of 80.6 dB. These values far exceed the WHO recommended daily safe limit of 65 dB, indicating persistent and widespread noise pollution across Davao City. The highest average daily noise level was observed at the Davao International Airport, followed closely by other high-traffic areas such as Tibungco Public Market and Sasa Wharf.

Overall, Davao City exhibited significantly higher noise levels compared to Legazpi City, with average daily noise levels exceeding WHO thresholds across most locations. In Davao, the daily average noise levels consistently breach the WHO recommended limits of 65 dB, reflecting intensified urban activity. Noise levels in the Central Business District (CBD), public markets, and transportation hubs are particularly concerning, with daily averages often surpassing the WHO safe standard by 10–20 dB. The highest recorded values in Davao reach 88 dB during peak periods, indicating severe noise pollution attributed to heavy vehicular traffic, commercial activities, and industrial operations.

In comparison, Legazpi City demonstrated a more moderate noise environment, with daily averages closer to or within WHO standards across several locations. For instance, the Central Business District in Legazpi consistently maintains noise levels near the safe threshold of 70 dB, with only minor exceedances during peak hours. While specific zones, such as the public market and bus terminal, show elevated noise levels, these are less severe than their counterparts in Davao. Legazpi's residential neighborhoods also exhibit lower noise levels, generally staying within a 5–10 dB margin above the recommended standard, highlighting a relatively quieter urban setting compared to Davao.

When averaged across all locations, Davao's daily noise levels (approximately 80.6 dB) are substantially higher than Legazpi’s (approximately 67.2 dB). This stark contrast underscores Davao's challenges in managing noise pollution across its highly urbanized zones, particularly in transportation hubs and residential areas, where noise levels significantly impact public health and quality of life. Legazpi, on the other hand, demonstrates better control, with noise levels only marginally exceeding WHO standards in most areas.

The differences can be attributed to the scale of urbanization and the nature of economic activities in the two cities. Davao City, being a larger metropolitan area, faces more significant challenges in mitigating noise from high-density traffic, bustling markets, and industrial zones. Legazpi City, with its relatively smaller urban footprint, benefits from reduced noise sources and possibly more significant challenges in mitigating noise from high-density traffic, bustling markets, and industrial zones. Legazpi City, with its relatively smaller urban footprint, benefits from reduced noise sources and possibly more effective urban planning.

4. CONCLUSION AND RECOMMENDATIONS

Based on the results of the demographic, noise exposure, health impacts, and environmental noise level analyses, the following conclusions are drawn:

Vehicular noise pollution was observed to be significantly higher in Davao City due to its larger population, higher vehicle density, and industrial activities while Legazpi City, although smaller, have also experiencing rising noise levels due to increasing vehicular traffic, particularly in tourist and commercial zones.

Continuous exposure to noise pollution may have significant negative effects on physical health as it has affected physical health conditions due to sleep disturbances, headaches, and hearing loss, which noted to be pronounced in Davao City. The same has created anxiety and stress because of prolonged exposure to noise brought about by the traffic and industrial point sources which exacerbates psychological burden on its residents.

Both cities were observed by the respondents with minimal current noise mitigation measures and unfortunately, they were unaware of any noise reduction strategies implemented and if any, were widely perceived as low suggesting for a need for more wide efforts on noise management. The results implies that additional or enhanced noise reduction measures could significantly decrease noise pollution and its associated health impacts. The widespread support for stricter regulations in both cities were highly recommended by its respective residents in combatting noise pollutions. Although, industrial plants was noted as one of the sources, the measures to be implemented shall likewise include all types of vehicle including its accessorings such as the mufflers, wheels and horns as they were identified as primary contributors to noise in urban centers.

In order to address the adverse effects of noise pollution, the following recommendations among others are formulated:

1. **Stricter noise mitigation measures**. This includes launching public awareness campaigns to educate residents on the impacts of noise and the importance of compliance with noise ordinances. Enforcement of noise regulations must also be more stringent. Additionally, intensify futher the implementation of government policies and ordinances such as for horns, control wheel-to-road friction through speed limits, and the use of loud mufflers or excessive honking in residential, schools and hospitals.

Regular noise monitoring should be conducted across urban areas to assess the effectiveness of noise reduction measures. These assessments would inform policymakers and implementors on noise levels and that will guide them in implementing better strategies for controlling urban noise pollution.

Engineering solutions such as soundproofing materials, acoustical insulation, double-glazed windows, sealing gaps in buildings, planting trees as sound barriers, and creating better zoning codes for urban areas can all contribute to reducing noise exposure. Somehow, these strategies will lead to quieter and healthier urban environments.

2. **Establishment of Green buffers**. Trees and ornamental plants are known for its effective control in noise pollution other than for carbon sequestration. This has to be included in the comprehensive land use plan (CLUP) of the Local Government Units in order to receive a sustainable regular budget from the government. The green buffers which were already established maybe further enhanced and maintained while other areas maybe added with a new greener noise barriers.

3. **Public Health interventions**. Given the significant physical and mental health impacts of noise exposure, it is important to develop targeted public health interventions. These includes some initiatives aimed at reducing noise in vulnerable areas, promoting stress management programs, and providing support services for individuals suffering from noise-induced health issues such as sleep disturbances, headaches, and anxiety. Awareness campaigns can also inform the public about the links between noise pollution and health, emphasizing the importance of noise reduction measures.

4. **Research and Monitoring**. To better understand the long-term health effects of urban noise exposure, it is imperative that longitudinal studies be conducted which may include the physical and mental health of residents over time, evaluate the effectiveness of noise reduction measures, and provide valuable data to guide future urban planning and public health policies.

5. **Stakeholders Participation**. The implementation of noise reduction technologies should be encouraged, especially in the transportation sector can help lower urban noise levels. Although, there is a strict government implementation, however, the cooperation of all stakeholders is very important for the success of the program.

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