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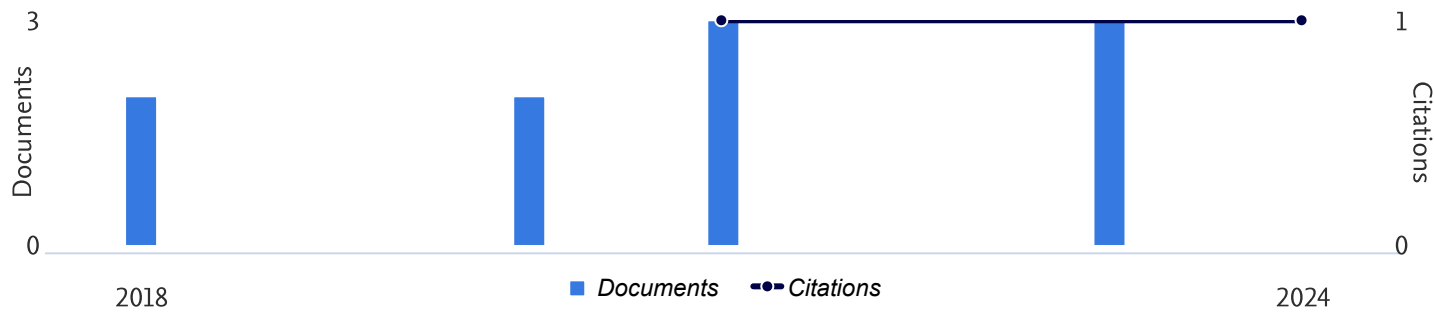


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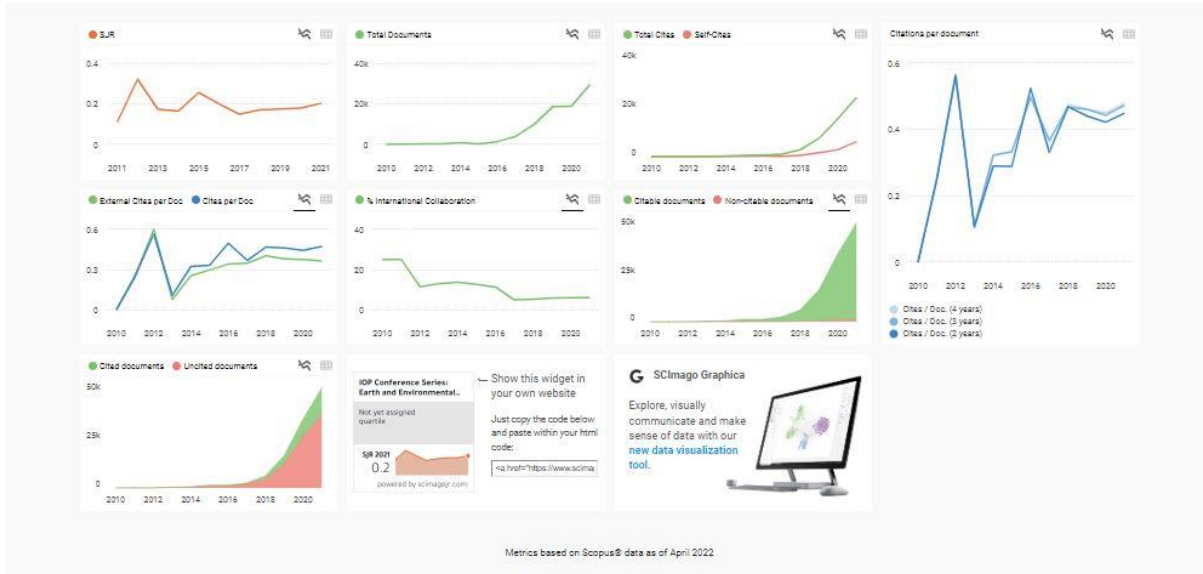
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Effect of distance of housing to airport on noise disturbances level (case: housing around Soekarno-Hatta International Airport)

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Abstract. This study aims to identify the effect of distance of housing to the airport on the level of noise disturbance. The airport is an area of land or water with certain boundaries that used as a place to landing and take-off. As a vital and dynamic object, the airport's surrounding has to accommodate its future developments and keep secure by keeping away from residential areas. And vice versa, for the convenience of its residents, these housings need to be regulated at a minimum distance from the airport. Its residents will be affected by noise due to aircraft traffic activity. Noise is unwanted sound at a certain level and time causing interference. Soekarno-Hatta International Airport was chosen considering the high intensity of aircraft traffic with large aircraft dimensions and high noise interference. Dimensions of noise disorders studied include physical disorders, communication disorders, sleep disorders, disruption of activity, and emotional disorders. This research is quantitative using a survey-questionnaire method. The number of samples was determined using the Lemeshow formula of 96 respondents. The results show that the effect of distance on the noise disturbance level for all the dimensions mentioned above is significant. This result emphasizes the need for a minimum distance limitation between housing and the airport.

1. Introduction

Housing grows along with population growth. This condition is shown by the growth of housing in vulnerable areas around airports. Residential areas are often very close to the aircraft runway [1]. The proximity of the housing area around the airport will cause noise disturbance due to aircraft activities as an undesirable side effect of aircraft operations. Active airports usually tend to increase the frequency of aircraft flights every year. As this flight frequency increases, it will also result in high levels of noise at airports. Continual exposure to noise from various activities in the airport environment can result in physiological and psychological disorders in humans [2]. Based on the distance of the housing area to the airport, this study aims to identify the effect of the distance of the housing area to the airport on the perception of noise disturbance levels.

Noise is an unwanted sound in an activity at a certain level and time because it causes interference. The sources of noise include moving vehicles such as airplanes. The source of noise due to flight activity is a dynamic noise. The type of noise due to flight activity is an intermittent noise. Aircraft noise is produced from four sources, namely the propeller, aerodynamic, engine exhaust, and engine



vibration [3]. Aircraft noise is considered an important source of noise pollution that negatively impacts residents around airports [4]. The level of noise perceived by a person is directly proportional to the distance to the noise source. The closer to the noise source, the greater the noise level will be. Based on the noise level quality standard, the allotment of housing areas and settlements has a maximum limitation of 55 dB [5].

The disturbance is a state of displeasure that is experienced or happening to someone. Noise disturbance can affect humans, both in the short and long term. The effects of noise are categorized into two, namely auditory and non-auditory [6].

The auditory system is a system that is responsible for the sense of hearing. The auditory effect is an influence on hearing-related health such as decreased sensitivity to sounds or noises, for example, reduced or loss of the hearing ability of a person [7]. Examples of hearing disruptions due to airplane activities are buzzing ears and headaches. Meanwhile, non-auditory disruptions are as follows.

- **Communication Disruption**

Noise exposure can reduce a person's ability to communicate. Communication problems such as difficulties in conversation due to aircraft noise interruption. Noise can cause an interruption in outdoor conversation or communication. Communication disorders might cause misunderstandings and decrease the quality of information conveyed to the listener or the interlocutor [8]. Communication disruption being linked to activity disturbance can cause a loss of focus.

- **Sleeping Disruption**

Laszlo [9] qualitatively reviewed 41 papers on human reactions to environmental noise exposure changes, showing that the most common outcomes investigated were sleep disturbance. Sleeping time disruption is a concern, especially for people who are exposed to aircraft noise at night. The effect of noise during a sleeping time in the form of sleep difficulties (insomnia), easily awakened from sleep, and low-quality rest [10]. Exposure to noise can reduce sleep quality and create minimum sleep duration at night, which will have an impact on concentration disturbance and reduced energy for several days. For these reasons, noise-induced sleep disturbance is considered the most deleterious non-auditory effect of environmental noise exposure [11].

- **Activity Disturbance**

The influence of noise experienced by a person can lead to concentration disorder that would reduce productivity in their activities. Activities that require more concentration such as working and studying will be disturbed by noise [12]. The ability or performance of someone in completing their work will be decreased and slower when exposed to noise on a long term [13].

- **Psychological and Emotional Disturbance**

Noise can cause psychological disorders on a person. Psychological disorders are a form of emotional expression [14]. Psychological disorders can include irritation, shock, irritability, fatigue, and low quality of concentration. Irritation is someone's subjective reaction which is often reported as a response to environmental noise. Furthermore, emotional conditions can affect activities carried out by the person.

Noise Area Limitation around Soekarno-Hatta International Airport, noise limitation area is categorized into three areas [15].

- **Noise Area Level I**

In this area, the airplane noise index is at $70 \leq \text{WECPNL} < 75$. Land and space in this area are utilized from various kinds of activities and/or buildings, except school and hospital.

- **Noise Area Level II**

In this area, the airplane noise index is at $75 \leq \text{WECPNL} < 80$. The land and space in this area are utilized for various kinds of activities and/or buildings, except for schools, hospitals, and housings. Schools, hospitals, and housings should be fitted with noise insulation.

- Noise Area Level III

In this area, the airplane noise index is at WECPNL ≥ 80 . The land and space in this area are utilized to build airport buildings or facilities fitted with noise insulation. Besides that, this area is also utilized as a green area or environmental control facility.

The airport layout is spatial that relates to the aviation operational space, which is the layout of aviation safety that has been regulated by the ICAO standard (International Civil Aviation Organization). This standard is the recommendation implementation applied in the aviation world. Where the environmental area around the airport is barrier-free for aircraft to take off, landing, and holding is at a radius of 0-4000 meters. In this standard, there is a measurement of noise disturbance level, which is measured at a distance of 300 meters parallel to the runway, as well as 1000 meters, 2000 meters, 3000 meters, and 4000 meters from the runway.

2. Research methodology

This research is categorized as quantitative research. The analysis units are the individual housing residents around Soekarno-Hatta International airport. In measuring the effect of housing distance to the airport on the perception of the level of noise disturbance, the survey-questionnaire method was used. The time of research is April to May 2020. Respondents of 96 people were determined by using the Lemeshow formula because the total population is unknown. Assuming $p=0.5$ with a 95% confidence level and Z value at $1-\alpha/2$ with a confidence level of $\alpha=0.05$, the result is 1.96 which means that 96 samples are needed.

The questionnaire as a measurement tool is directed to obtain data such as distances from housing to airport and perception on noise disturbance level. Housing around Soekarno-Hatta International Airport was chosen because this airport has dense flight activities and surrounded by numbers of complex housings around it.

3. Results and discussion

3.1. Distance from housings to airport

According to the result, obtained distribution of distance from housings to the airport. To know the location of residents affected by noise disturbance. The closest distance from housings to the airport is 300 meters, meanwhile, the longest distance is 9.8 kilometres with a distribution as shown in Table 1.

Table 1. Distribution of distance from housings to airport.

| Distance from housings to airport | Number of Respondents | Percentage (%) |
|-----------------------------------|-----------------------|----------------|
| < 1 km | 11 | 11% |
| 1 – 2 km | 21 | 22% |
| 2 – 3 km | 13 | 14% |
| 3 – 4 km | 12 | 13% |
| >4 km | 39 | 40% |
| Total | 96 | 100% |

The majority of distances from housings to the airport are at a distance of >4 km with a percentage of 40%. Based on the International Civil Aviation Organization (ICAO) measurement, the longest disturbance occurred at a distance of 4 kilometres. In the study area, 60% of the respondent is categorized as risky because their distance from the airport is less than 4 kilometres. The closer to the distance from housings to the airport, the greater the noise level will be.

3.2. Perception on noise disturbance level

Perception is an individual subjective valuation based on their feelings. Perception is one aspect for humans in responding to the various phenomena surrounding it. Each individual has a different perception. Perception of disturbance includes physical condition, communication disturbance, sleeping disorders, activity disturbance, and emotional condition disorders. For more details see Table 2.

Table 2. Perception on noise disturbance.

| Variables | Statements | Affirmation | Neutral | Disagreement |
|--|--|-------------|---------|--------------|
| | | Score (%) | | |
| Disturbance on Physical Condition | Buzzing Ear | 55.2 | 28.1 | 16.7 |
| | Lower Hearing Ability | 18.8 | 37.5 | 43.8 |
| | Headache | 15.6 | 31.3 | 53.1 |
| Communication Disturbance | Difficulty to hear interlocutor | 68.8 | 19.8 | 11.5 |
| | Difficulty to obtain information out of a conversation | 72.9 | 15.6 | 11.5 |
| | Loudening voice when talking | 76.0 | 10.4 | 13.5 |
| Disturbance during Sleeping/Resting time | Disturbed when sleeping | 36.5 | 34.4 | 29.2 |
| | Often awoken during sleeping | 34.4 | 32.3 | 33.3 |
| | Unable to rest comfortably during the day | 24.0 | 27.1 | 49.0 |
| Disturbance during activity performance (Working/Studying) | Disturbed during working | 36.0 | 40.0 | 24.0 |
| | Disturbed during studying | 58.7 | 23.9 | 17.4 |
| | Disturbed working concentration | 38.0 | 44.0 | 18.0 |
| Emotional Condition Disturbance | Disturbed studying concentration | 52.2 | 21.7 | 26.1 |
| | Feeling upset | 38.5 | 29.2 | 32.3 |
| | Easily angry | 7.3 | 29.2 | 63.5 |
| | Feeling shocked | 41.7 | 18.8 | 39.6 |

The most prominent disorders on the physical condition are buzzing ears (55.2%). Communication disturbance occurs on every indicator. The majority of disturbance during sleeping/resting time occurs in the form of feeling disturbed when sleeping (36.5%) and often awoken during sleeping (34.4%). During activities performances, the dominant disturbance is felt when working and studying, concentration during learning is also disturbed. As for emotional conditions disturbance, it occurs in the form of feeling upset (38.5%) and shocked (41.7%).

4. Analysis and discussion

4.1. Noise disturbance level perception

Perception is an individual subjective valuation towards a condition. Perception of noise disturbance level is classified in 3 classes, namely high, medium, and low. Perception of noise disturbance is shown in Table 3.

Table 3. Noise disturbance level perception.

| Percentage of Noise Disturbance Level (%) | | Interval |
|---|------|--------------------|
| High | 25,0 | High (1) = 21-35 |
| Medium | 63,5 | Medium (2) = 36-50 |
| Low | 11,5 | Low (3) = 51-63 |

Based on Table 3 noise disturbance level perceived by housings residents around Soekarno-Hatta International Airport is at a medium level. This condition is caused by the existence of residential adaptation efforts with the environment around the airport. Most of the perception of noise disturbance by the residents around the Soekarno-Hatta International Airport.

4.2. *The impact of housing distance to the airport on noise disturbance level perception*

The perception of noise disturbance level in settlements is influenced by many things, one of the distances of settlements to the airport. Seeing the development of the region, especially the settlements around Soekarno-Hatta International Airport, this allows the influence of the perceived inhabitants of the surrounding airports. Statistical test result on the impact of housing distance to the airport on noise disturbance level perception is significant as shown in Table 4. This result shows that the distance from housing to the airport influences perceived disturbance received by housing residents around Soekarno-Hatta International Airport.

Table 4. Impact of distance on noise disturbance level perception.

| Noise Disturbance Perception | Significance Value |
|---|--------------------|
| Disturbance on Physical Condition | 0.000 |
| Disturbance during Communication | |
| Disturbance during Sleeping/Resting | |
| Disturbance during Activity Performances (working/studying) | |
| Disturbance on Emotional Condition | |
| | |

An airport is a vital object. To accommodate its development, a regulation to manage housing distance from it is required. Based on noise regulation of the Soekarno-Hatta International Airport are based on the ICAO standard, we can see numbers of housings. The existence of these housings will affect the noise disturbance level perceived by the residents. The environmental area around the airport is barrier-free for aircraft to take off, landing, and holding. The existence of these housings will affect the noise disturbance level perceived by the residents. Because of that, a decision regarding housing area management based environmental area around the airport.

5. Conclusion

The growth of housing around the airport affects the noise disturbance of the residents of the housing. There is a significant influence of housing distance to the airport towards noise level perception. The closer the distance from housing to the airport, the higher noise disturbance level perceived by the residents will be. The experienced noise disturbance level includes physical condition disorders such as buzzing ears, communication disturbance, activity disturbance, and emotional condition disturbance. Based on that, an affirmation of minimum distance limitation and housing area management around the airport is highly required.

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Effect of distance of housing to airport on noise disturbances level (case: housing around Soekarno-Hatta International Airport)

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Abstract. This study aims to identify the effect of distance of housing to the airport on the level of noise disturbance. The airport is an area of land or water with certain boundaries that used as a place to landing and take-off. As a vital and dynamic object, the airport's surrounding has to accommodate its future developments and keep secure by keeping away from residential areas. And vice versa, for the convenience of its residents, these housings need to be regulated at a minimum distance from the airport. Its residents will be affected by noise due to aircraft traffic activity. Noise is unwanted sound at a certain level and time causing interference. Soekarno-Hatta International Airport was chosen considering the high intensity of aircraft traffic with large aircraft dimensions and high noise interference. Dimensions of noise disorders studied include physical disorders, communication disorders, sleep disorders, disruption of activity, and emotional disorders. This research is quantitative using a survey-questionnaire method. The number of samples was determined using the Lemeshow formula of 96 respondents. The results show that the effect of distance on the noise disturbance level for all the dimensions mentioned above is significant. This result emphasizes the need for a minimum distance limitation between housing and the airport.

1. Introduction

Housing grows along with population growth. This condition is shown by the growth of housing in vulnerable areas around airports. Residential areas are often very close to the aircraft runway [1]. The proximity of the housing area around the airport will cause noise disturbance due to aircraft activities as an undesirable side effect of aircraft operations. Active airports usually tend to increase the frequency of aircraft flights every year. As this flight frequency increases, it will also result in high levels of noise at airports. Continual exposure to noise from various activities in the airport environment can result in physiological and psychological disorders in humans [2]. Based on the distance of the housing area to the airport, this study aims to identify the effect of the distance of the housing area to the airport on the perception of noise disturbance levels.

Noise is an unwanted sound in an activity at a certain level and time because it causes interference. The sources of noise include moving vehicles such as airplanes. The source of noise due to flight activity is a dynamic noise. The type of noise due to flight activity is an intermittent noise. Aircraft noise is produced from four sources, namely the propeller, aerodynamic, engine exhaust, and engine



vibration [3]. Aircraft noise is considered an important source of noise pollution the negatively impact resident around airport [4]. The level of noise perceived by a person is directly proportional to the distance to the noise source. The closer to the noise source, the greater the noise level will be. Based on the noise level quality standard, the allotment of housing areas and settlements has a maximum limitation of 55 dB [5].

The disturbance is a state of displeasure that is experienced or happening to someone. Noise disturbance can affect humans, both in the short and long term. The effects of noise are categorized into two, namely auditory and non-auditory [6].

The auditory system is a system that is responsible for the sense of hearing. The auditory effect is an influence on hearing-related health such as decreased sensitivity to sounds or noises, for example, reduced or loss of the hearing ability of a person [7]. Examples of hearing disruptions due to airplane activities are buzzing ears and headaches. Meanwhile, non-auditory disruptions are as follows.

- **Communication Disruption**

Noise exposure can reduce a person's ability to communicate. Communication problems such as difficulties in conversation due to aircraft noise interruption. Noise can cause an interruption in outdoor conversation or communication. Communication disorders might cause misunderstandings and decrease the quality of information conveyed to the listener or the interlocutor [8]. Communication disruption being linked to activity disturbance can cause a loss of focus.

- **Sleeping Disruption**

Laszlo [9] qualitatively reviewed 41 papers on human reactions to environmental noise exposure changes, showing that the most common outcomes investigated were sleep disturbance. Sleeping time disruption is a concern, especially for people who are exposed to aircraft noise at night. The effect of noise during a sleeping time in the form of sleep difficulties (insomnia), easily awakened from sleep, and low-quality rest [10]. Exposure to noise can reduce sleep quality and create minimum sleep duration at night which will have an impact on concentration disturbance and reduced energy for several days. For these reasons, noise-induced sleep disturbance is considered the most deleterious non-auditory effect of environmental noise exposure [11].

- **Activity Disturbance**

The influence of noise experienced by a person can lead to concentration disorder that would reduce productivity in their activities. Activities that require more concentration such as working and studying will be disturbed by noise [12]. The ability or performance of someone in completing their work will be decreased and slower when exposed to noise on a long term [13].

- **Psychological and Emotional Disturbance**

Noise can cause psychological disorders on a person. Psychological disorders are a form of emotional expression [14]. Psychological disorders can include irritation, shock, irritability, fatigue, and low quality of concentration. Irritation is someone's subjective reaction which is often reported as a response to environmental noise. Furthermore, emotional conditions can affect activities carried out by the person.

Noise Area Limitation around Soekarno-Hatta International Airport, noise limitation area is categorized into three areas [15].

- **Noise Area Level I**

In this area, the airplane noise index is at $70 \leq \text{WECPNL} < 75$. Land and space in this area are utilized from various kinds of activities and/or buildings, except school and hospital.

- **Noise Area Level II**

In this area, the airplane noise index is at $75 \leq \text{WECPNL} < 80$. The land and space in this area are utilized for various kinds of activities and/or buildings, except for schools, hospitals, and housings. Schools, hospitals, and housings should be fitted with noise insulation.

- Noise Area Level III

In this area, the airplane noise index is at WECPNL ≥ 80 . The land and space in this area are utilized to build airport buildings or facilities fitted with noise insulation. Besides that, this area is also utilized as a green area or environmental control facility.

The airport layout is spatial that relates to the aviation operational space, which is the layout of aviation safety that has been regulated by the ICAO standard (International Civil Aviation Organization). This standard is the recommendation implementation applied in the aviation world. Where the environmental area around the airport is barrier-free for aircraft to take off, landing, and holding is at a radius of 0-4000 meters. In this standard, there is a measurement of noise disturbance level, which is measured at a distance of 300 meters parallel to the runway, as well as 1000 meters, 2000 meters, 3000 meters, and 4000 meters from the runway.

2. Research methodology

This research is categorized as quantitative research. The analysis units are the individual housing residents around Soekarno-Hatta International airport. In measuring the effect of housing distance to the airport on the perception of the level of noise disturbance, the survey-questionnaire method was used. The time of research is April to May 2020. Respondents of 96 people were determined by using the Lemeshow formula because the total population is unknown. Assuming $p=0.5$ with a 95% confidence level and Z value at $1-\alpha/2$ with a confidence level of $\alpha=0.05$, the result is 1.96 which means that 96 samples are needed.

The questionnaire as a measurement tool is directed to obtain data such as distances from housing to airport and perception on noise disturbance level. Housing around Soekarno-Hatta International Airport was chosen because this airport has dense flight activities and surrounded by numbers of complex housings around it.

3. Results and discussion

3.1. Distance from housings to airport

According to the result, obtained distribution of distance from housings to the airport. To know the location of residents affected by noise disturbance. The closest distance from housings to the airport is 300 meters, meanwhile, the longest distance is 9.8 kilometres with a distribution as shown in Table 1.

Table 1. Distribution of distance from housings to airport.

| Distance from housings to airport | Number of Respondents | Percentage (%) |
|-----------------------------------|-----------------------|----------------|
| < 1 km | 11 | 11% |
| 1 – 2 km | 21 | 22% |
| 2 – 3 km | 13 | 14% |
| 3 – 4 km | 12 | 13% |
| >4 km | 39 | 40% |
| Total | 96 | 100% |

The majority of distances from housings to the airport are at a distance of >4 km with a percentage of 40%. Based on the International Civil Aviation Organization (ICAO) measurement, the longest disturbance occurred at a distance of 4 kilometres. In the study area, 60% of the respondent is categorized as risky because their distance from the airport is less than 4 kilometres. The closer to the distance from housings to the airport, the greater the noise level will be.

3.2. Perception on noise disturbance level

Perception is an individual subjective valuation based on their feelings. Perception is one aspect for humans in responding to the various phenomena surrounding it. Each individual has a different perception. Perception of disturbance includes physical condition, communication disturbance, sleeping disorders, activity disturbance, and emotional condition disorders. For more details see Table 2.

Table 2. Perception on noise disturbance.

| Variables | Statements | Affirmation | Neutral | Disagreement |
|--|--|-------------|---------|--------------|
| | | Score (%) | | |
| Disturbance on Physical Condition | Buzzing Ear | 55.2 | 28.1 | 16.7 |
| | Lower Hearing Ability | 18.8 | 37.5 | 43.8 |
| | Headache | 15.6 | 31.3 | 53.1 |
| | Difficulty to hear interlocutor | 68.8 | 19.8 | 11.5 |
| Communication Disturbance | Difficulty to obtain information out of a conversation | 72.9 | 15.6 | 11.5 |
| | Loudening voice when talking | 76.0 | 10.4 | 13.5 |
| | Disturbed when sleeping | 36.5 | 34.4 | 29.2 |
| Disturbance during Sleeping/Resting time | Often awoken during sleeping | 34.4 | 32.3 | 33.3 |
| | Unable to rest comfortably during the day | 24.0 | 27.1 | 49.0 |
| | Disturbed during working | 36.0 | 40.0 | 24.0 |
| Disturbance during activity performance (Working/Studying) | Disturbed during studying | 58.7 | 23.9 | 17.4 |
| | Disturbed working concentration | 38.0 | 44.0 | 18.0 |
| | Disturbed studying concentration | 52.2 | 21.7 | 26.1 |
| | Feeling upset | 38.5 | 29.2 | 32.3 |
| Emotional Condition Disturbance | Easily angry | 7.3 | 29.2 | 63.5 |
| | Feeling shocked | 41.7 | 18.8 | 39.6 |

The most prominent disorders on the physical condition are buzzing ears (55.2%). Communication disturbance occurs on every indicator. The majority of disturbance during sleeping/resting time occurs in the form of feeling disturbed when sleeping (36.5%) and often awoken during sleeping (34.4%). During activities performances, the dominant disturbance is felt when working and studying, concentration during learning is also disturbed. As for emotional conditions disturbance, it occurs in the form of feeling upset (38.5%) and shocked (41.7%).

4. Analysis and discussion

4.1. Noise disturbance level perception

Perception is an individual subjective valuation towards a condition. Perception of noise disturbance level is classified in 3 classes, namely high, medium, and low. Perception of noise disturbance is shown in Table 3.

Table 3. Noise disturbance level perception.

| Percentage of Noise Disturbance Level (%) | Interval |
|---|----------|
| High | 25,0 |
| Medium | 63,5 |
| Low | 11,5 |

Based on Table 3 noise disturbance level perceived by housings residents around Soekarno-Hatta International Airport is at a medium level. This condition is caused by the existence of residential adaptation efforts with the environment around the airport. Most of the perception of noise disturbance by the residents around the Soekarno-Hatta International Airport.

4.2. *The impact of housing distance to the airport on noise disturbance level perception*

The perception of noise disturbance level in settlements is influenced by many things, one of the distances of settlements to the airport. Seeing the development of the region, especially the settlements around Soekarno-Hatta International Airport, this allows the influence of the perceived inhabitants of the surrounding airports. Statistical test result on the impact of housing distance to the airport on noise disturbance level perception is significant as shown in Table 4. This result shows that the distance from housing to the airport influences perceived disturbance received by housing residents around Soekarno-Hatta International Airport.

Table 4. Impact of distance on noise disturbance level perception.

| Noise Disturbance Perception | Significance Value |
|-------------------------------------|--------------------|
| Disturbance on Physical Condition | 0.000 |
| Disturbance during Communication | |
| Disturbance during Sleeping/Resting | |
| Disturbance during Activity | |
| Performances (working/studying) | |
| Disturbance on Emotional Condition | |

An airport is a vital object. To accommodate its development, a regulation to manage housing distance from it is required. Based on noise regulation of the Soekarno-Hatta International Airport are based on the ICAO standard, we can see numbers of housings. The existence of these housings will affect the noise disturbance level perceived by the residents. The environmental area around the airport is barrier-free for aircraft to take off, landing, and holding. The existence of these housings will affect the noise disturbance level perceived by the residents. Because of that, a decision regarding housing area management based environmental area around the airport.

5. Conclusion

The growth of housing around the airport affects the noise disturbance of the residents of the housing. There is a significant influence of housing distance to the airport towards noise level perception. The closer the distance from housing to the airport, the higher noise disturbance level perceived by the residents will be. The experienced noise disturbance level includes physical condition disorders such as buzzing ears, communication disturbance, activity disturbance, and emotional condition disturbance. Based on that, an affirmation of minimum distance limitation and housing area management around the airport is highly required.

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