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# Noise Exposure Assessment and Estimated Excess Risk of Cabin Personnel in the Locomotive-CC205

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## ABSTRACT

Train is one of the most environmentally friendly mode of transportation. However, currently there are still some types of locomotive designed to be opened (such as CC201); hence, the generated noise can potentially affect the health of the workers, particularly cabin personnel (i.e. train driver and assistant of driver). The objective of this study are to analyze the noise levels exposed to cabin personnel and to estimate the excess risks of occupational noise-induced hearing loss in the locomotive. The cabin personnel were considered as exposed group while the office workers of the train station (Poncol Station) was the control group. The noise levels were measured continuously during the working hours using noise dosimeter. The audiometry test was also conducted to both case and control group. The data were analyzed using chi-square statistical test and NIOSH 1998 method of excess risk estimation. The measured noise exposure level in the locomotive-CC205 during the working hours (4-5 hours) ranged from 71.2 dBA until 123.4 dBA. However, the excess risks of the respondents were only 0.75% higher than the control group. This might be due to the short working period of the participants (no more than 10 years). The noise exposure to the case group workers were higher than time-weighted average noise level. Based on the chi-square statistical test, it is concluded that the noise levels affect the noise-induced hearing loss of the cabin personnel.

***Keywords****: train, noise, noise-induced hearing loss, excess risk*

## INTRODUCTION

Competition in the era of globalization requires that every activity must pay attention to environmental aspects. This global orientation of global development demands the initiators and managers of the industry, both the manufacturing industry and the service industry to change the mindset and aspiration of its business activities toward modern, environmentally sound business concerning safety and health, including railway companies. The railways not only have a positive impact on the workers, but also the potential negative impacts such as health impacts due to noise and vibration. This situation will potentially affect the health of workers working around the railway or working in the station.

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Area Operation IV Semarang or abbreviated as DAOP IV Semarang and DAOP IV SM or D4 SM Release Tobu Hope is one of the Indonesian railway operations area, under PT Kereta Api Indonesia (Persero), or PT KAI, led by an Executive Vice President (EVP). The highest noise intensity is felt by train drivers because the cabin position is at a very close distance to the rail diesel engine.

Harrington[1] argued that noise can affect health such as hearing function, changes in the frequency of heartbeat, changes in blood pressure, and the level of sweat excretion. In addition, noise can also be associated with the occurrence of hypertension[2–4]. People who are exposed to noise, tend to have unstable emotions then emotional instability will lead to stress[2]. Yoon et al[5] also proved that noise in the work environment was closely related to mental health conditions. Long-term stress will cause the narrowing of blood vessels, so the heart must work harder pumping blood throughout the body. In a long time, blood pressure will rise, and this is called hypertension. Furthermore, it is found that there is significant associations between noise exposure, noise-induced hearing loss, and work-related accidents[6].

In this study the selected location is a cabin of train driver with the object of cabin personnel. The selected route was from Semarang to Tegal as a short-haul train at DAOP IV Semarang Poncol. The route of Semarang-Tegal was chosen because it was the longest path that can be reached from Semarang Station in one day. The objectives of this study are to analyze the noise levels exposed to cabin personnel and to estimate the excess risks of occupational noise-induced hearing loss in the locomotive.

## METHOD

This research was an analytic research comparing between case group and control group based on noise exposure. The history of exposure in this study can be known from the medical register or based on interviews of the study respondents. The sampling technique of respondents was done by using purposive sampling method with the object of cabin personnel in DAOP IV PT KAI short-distance route.

## DATA COLLECTION

**Noise Level Measurement:** The noise level data collection was done by direct measurement. Noise level measurement was conducted in the railway locomotive cabin of CC205 from Semarang to Tegal by placing the Noise Dosimeter on the cabin personnel. The reading was done every five seconds during the roundtrip. This reading was in accordance with Decree of Ministry of Environment No. 48/1996 on Noise Level Thresholds. Noise Dosimeter used in this study was Lutron DS-2013SD, that is capable of recording noise data. The noise data were recorded in the form of a diagram for easy reading. Measurement of noise data started from the initial departure station (the Semarang Poncol Station) until Tegal Station.

**Audiometry test:** Cabin personnel perform audiometric tests to determine the degree of deafness of cabin personnel as case group. The results were recorded in an audiogram, where the horizontal line represents the frequencies and vertical lines describing the intensity. This was also applied to officers at the Poncol Station as a control. The audiometric test organizing was assisted by audiologist and certified specialist technician. Cabin personnel were also asked to fill in some questions from questionnaires in the form of a complete list of questions about identity, health status, working period, working duration, residence history, and others with a definition of each question to facilitate the respondents to fill in the questionnaire.

Determination of respondents in the population used purposive sampling method with inclusion and exclusion criteria. Exclusion criteria are the characteristics of respondents who can not be included in the research, as for exclusion criteria, such as respondent refused to participate, respondent was sick or did not come during the study. Meanwhile, inclusion criteria are the characteristics of respondents who can be included or eligible for study, as for inclusion criteria, including:

1. **Age[7]:** Controlled by selecting workers aged 18-50 years. The older the working age the more vulnerable to exposure to work environment and occupational diseases.
2. **Working period[7]:** Controlled by selecting workers whose working period is >3 years due to the fragile working period of occupational diseases between 2-6 years.
3. **Health condition:** Controlled by selecting workers who have healthy status and no history of hearing diseases

Cabin personnel performed audiometric tests to determine the degree of perceived hearing threshold. Officer of the station who became the respondent was the officer with morning shift until the afternoon. Cabin personnel respondents were cabin personnel on duty as backup engineers. Questionnaire survey and audiometric inspection were done at the origin station (Semarang Poncol) for the station personnel whereas the office staff of UPT Crew Semarang for cabin personnel. The recording of the audiometry test results were carried out at frequencies from 500 Hz to 6000 Hz and taken average values to 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz each right ear and left ear. A reference value determined whether the respondent had normal hearing, light deafness, moderate hearing, or severe deafness according to the classification of hearing impairment degree.

## DATA ANALYSES

**Noise Level Assessment:** The noise level metric used was Leq (equivalent continuous noise level) in dBA and LN (statistic noise level) such as L5, L10, L50, L90. By definition, the L10 value is the noise level achieved for 10% of the measurement time and describes the peak

noise. The L50 value is the noise level achieved for 50% of the measurement time and describes the median (middle value) of the noise level. And the L90 is a noise level achieved for 90% of the measurement time, describing residual noise.

**Relation between Noise exposure and Hearing Loss:** In this case, the independent variable was noise and the dependent variable was hearing loss. Meanwhile Chi Square test was used to analyze the relationship between noise level and the status of hearing loss of cabin personnel. Chi-Square test is a statistical technique used to test the hypothesis when the population consists of two or more classes in the form of categorical data.

The significant level used is 95% with a significance value of 5%. Criteria value (p-value) generated was compared to the value of significance selected with the following criteria:

If Sig. > α, $H_0$ is accepted

If Sig. <α, $H_0$ is not acceptable yet

Or in sentence form is as follows:

$H_0$: There is no relationship between the noise level and the hearing impairment of cabin personnel

$H_1$: There is a relationship between the noise level and the hearing loss of cabin personnel

**Estimation of Excess Risks:** Attributable risk is another term from Risk Difference, Excess Risk, and also Rate Difference. Attributable risk is the level of disease in population who are exposed, reduced by people who are not exposed. In the current study, the respondents were those exposed to noise (cabin personnel) and those not exposed to noise (station officers). Excess Risk is the most relevant association measure when making decisions for individuals. For example, in determining whether workers who are working in the high noise section, analysis is carried out to determine the amount of risk of injury that must be borne by the worker 's participation in carrying out a job. The risk of developing a disease that can be caused by specific exposure, or how the disease occurred due to exposure to certain factors. Estimation of excess risk of hearing loss was calculated from the measured audiometric test data. The calculation was based on 1998 National Institute of Occupational Safety and Health model (NIOSH 1998)[8] because NIOSH is the most commonly used reference in Indonesia. These models determine the average hearing loss for the Frequency range (0.5-4.0 kHz) representing 0% and hearing 100% disability limit respectively. The lowest limit of 25 dBA is normal hearing. The calculation used an online calculator developed by Kavanagh[9,10] and can be accessed at http://www.occupationalhearingloss.com.

## RESULTS AND DISCUSSION

**Locomotive-CC201 Specification (Semarang-Tegal Route):** Kaligung Railway (KA Kaligung) or Locomotive CC201 is one of the trains owned by PT KAI serving Semarang-Tegal and Tegal-Semarang route as far as 148.1 km. There are 50 bridges traversed by KA Kaligung along the journey from Semarang Poncol Station to Tegal Station. Settlements traversed by KA Kaligung is a settlement located close to the area of the station, as well as settlements located in urban areas. The train passes several stations, namely Semarang Poncol Station, Weleri Station, Pekalongan Station, Pemalang Station, and finally at Tegal Station.

Kaligung Train is one type of economic train that has air conditioner and two-seat for more comfort to passengers. Beginning February 1, 2012 PT KAI DAOP 4 Semarang adds KA Kaligung has two roundtrips Tegal-Semarang and is usually pulled by Locomotive CC201. KA Kaligung's locomotive numbered CC201 means that it is using two bogies with each three driving wheels and using electrically series diesel locomotive type 01. The average travel time from Semarang to Tegal is for 2.5 hours.

**Noise Level Assessment:** The statistical results of the cabin noise level rating of KA Kaligung are shown on the graph in Figure 1.

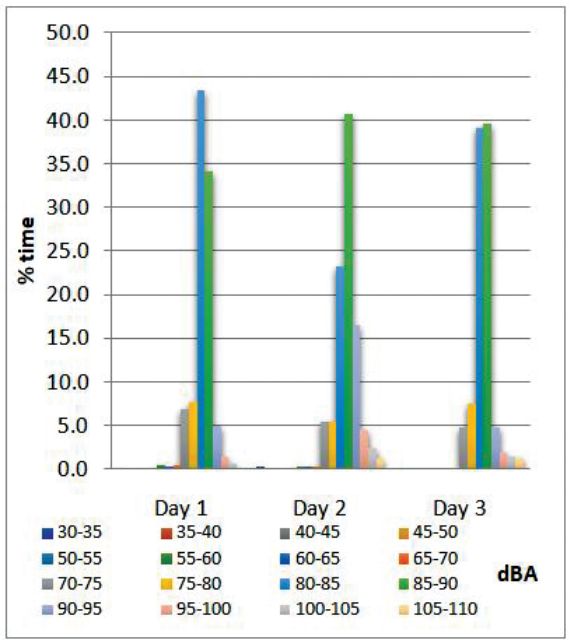


**Figure 1: Statistics of Noise Level in the Cabin of Locomotive-CC201**

On the first day (Friday), 43.9%, 1.4%, 34.5%, and 6.9% of travel time along the engineering department accounted for 80-85 dBA, 95-100 dBA, 85-90 dBA, and 70-75 dBA, respectively. If it is compared to second day (Saturday) and third day (Sunday), there was noise level ranged from 105-110 dBA accounted for 1.2% of travel time. It can be inferred that during weekend, the noise level became higher than weekday (Friday). Because noise levels often fluctuate over a wide range and over time, single-value descriptors like Leq become important. The statistic results of the measurement of the noise level in the driver cabin is described in Figure 2. The Leq in the locomotive cabin was ranged from 87.5 to 93 dBA, while L10 was more than 90 dBA. According to the field observation, the noise source were not only came from the engine, but also the horn, rolling noise, aerodynamic noise, background noise, and other noise source. According to Platon and Tudor[9], the noise exposure from diesel engine and the locomotive air compressor is a risk factor for the driver in the first place because it can affect concentration and decision of the driver.

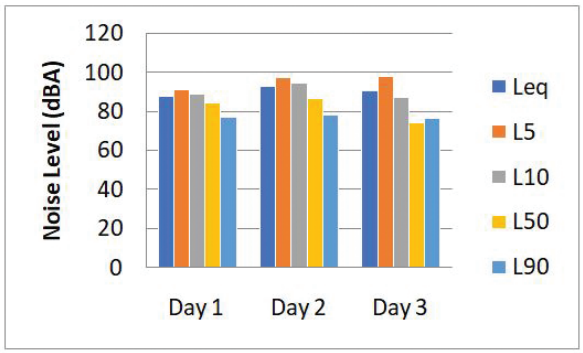


**Figure 2: Summary of Noise Level Data Measurement in the Cabin of Locomotive-CC201**

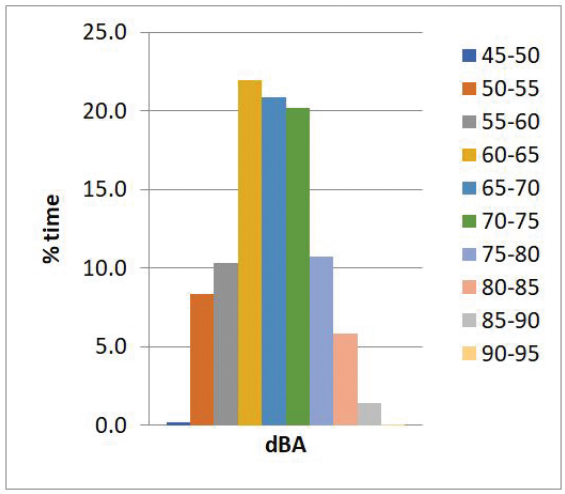


**Figure 3: Noise Level Data Measurement in Semarang Poncol Station**

Mewanwhile, in the Semarang Poncol Station, the measured noise level (Leq) was 74.78 dBA, L10 was 78.5 dBA, L50 was 67.2 dBA and L90 was 56.1 dBA. It can be inferred that noise at the station was less than the threshold limit for 8 working hours and was relatively lower than the noise in the locomotive or driver cabin. Therefore, the officers in Poncol Station can be considered as control group of this study.

**Relation between Noise Exposure and Hearing Loss:** Chi Square Analysis of Noise and Hearing Loss Relationships. Using the following hypothesis:

$H_0$: Noise level has no effect on hearing loss

$H_1$: Noise level affects hearing loss

At the level of significance $\alpha = 0.05$ if the value of Sig. $<\alpha$, $H_0$ is rejected, meaning that there is noise level effect on hearing loss. Based on the Chi-Square Tests table, it is obtained that Chi-square ($X$ ^ 2) = 7.680 and Sig. = .006 then $H_0$ is rejected so that in concluded at the level of significance 0.05 or 5%, there is noise level effect on hearing loss. According to the noise measurement in Semarang Poncol Station (inside the office), the noise level exposure was below 85 dBA (75 dBA). Meanwhile, in the cabin of locomotive CC-201 namely 87.5 – 93 dBA.

**Estimation of Excess Risks:** Based on the calculation, the average value of the highest estimated excess risk hearing loss is 0.75% for cabin personnel and 0% for station officers, with the equation of the 1998 NIOSH model. This model calculates the average excess hearing risk decrease in audiometric test frequency of 1, 2, 3 and 4 kHz. This finding was validated by the fact that the threshold test for both ears was the highest on the 4 kHz frequency for 60 cabin personnel. Detailed audiometric analysis based on the type of work also showed that more than 90% of station staff had no excess risk of hearing loss, while more than 30% of cabin personnel had excess risk of hearing loss. It can be concluded that the average excess risk estimation of cabin personnel hearing loss is higher than that of the control group (station officer) due to the influence of work hazard (noise) exposed to cabin personnel.

The meaning of the average value of 0.75% is that that people who exposed to noise (cabin personnel) are 0.75% more at risk of hearing loss, while 0% is estimated to be at risk of hearing loss to the station officers. In other words, cabin personnel are at risk of

hearing loss if they continue to be in a state of the same noise exposure, while station officers are not at risk. This is due to the considerable noise level difference between the locomotive cabin that exceeds the threshold (±90 dB) felt by cabin personnel, and the station noise level is still below the threshold (75 dB). However, the risk of 0.75% might be considered as underestimation because the working period of cabin personnel was relatively low (no more than 10 years).

Presbycusis is sensorineural hearing loss or hearing loss naturally caused by aging[8]. In audiometry, presbycusis has no effect on the frequency of 4000 Hz but higher frequency. From audiometric test data it is known that there is a relationship between decreased hearing ability and age. For example, a 46-year-old respondent with 4.06% hearing ability and 27.24% presbycusis. This means that there is a high potential that the respondent is affected by decreased hearing ability due to aging.

Excess risk estimation of hearing loss in cabin personnel causes consideration of risk management actions. Risks that occur within PT KAI are an integral part of the organizational process, risk control is an integral part of management's responsibilities, in ensuring the achievement of organizational goals. Therefore, risk control can improve the effectiveness and efficiency of management, because all the risks that can disturb the organizational process have been well identified, then the way to overcome the disruption of organizational processes has been anticipated in advance, so that if the disturbance does occur then the organization is ready to handle it properly. A proper measure to control occupational noise has been conducted in Norwegian railway company that the risk of noise-induced hearing loss of the workers during period 1991-2014 has been negligible[11]. This can be adapted to Indonesian Railway Company (PT KAI) if there is further countermeasure to noise exposure toward railway workers. For optimizing the investment, a thorough life-cycle assessment can be conducted because the impacts and values of noise mitigations can vary from urban area to rural area network[12].

## CONCLUSIONS

The noise sources on the Kaligung Locomotive CC201 which can affect the hearing of cabin personnel are the horns (110-123.4 dBA), the sound of the rail engines (86.4-99.6 dBA), and during braking (71.2 dBA). Based on analysis of Chi Square Test, the risk factors that can cause hearing impairment in DAOP IV Semarang (KA Kaligung Locomotive CC201) was the noise level, Estimation of excess risk of hearing loss in cabin personnel in DAOP IV Semarang by 0.75% that is higher than control group (0%).

**Conflict of Interest:** Nil

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**Ethical Clearance:** This study did not take ethical clearance since it is not a biomedical research.

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