Extended Noise Exposure Induce Health Impairment in Machinist at Bandung

N Sylviana¹, K Devani², D Fahmiasyari³, Y A Dewi⁴, R Andean⁵, R Anggraini ⁶, V M Tawaran⁷

¹, ², ⁵ Department of Anatomy Physiology and Biology Cell, Faculty Medicine, Universitas Padjadjaran

⁴, ⁶ Department of Ear, Nose and Throat-Head and Neck, Faculty Medicine, Universitas Padjadjaran/ Dr. Hasan Sadikin Hospital, Bandung

Abstract. Noise at certain levels at long intervals, will be harmful to health, resulting in auditory and non-auditory impairment. This study is aimed to determine the extended noise exposure induce health impairment in machinist. This analytic study was involved 52 machinist there were chosen as samples using non-probability sampling technique with consecutive sampling method, intensity measurement was done using sound level meter on the locomotive. Interviews were done on the subjects about work length and subjective health complaints. The data were analyzed using Chi square to determine the relationship between the two variables. The noise intensity in the locomotives ranged from 70.9–107.1 dB. The proportion of subjects with work length of <10 years and ≥10 years were 42.9% and 57.1% consecutively. The proportion of hearing loss 2(3, 3%) of machinists whose work less than 10 year, 4 (7, 7%) of machinists whose work between 10 to 19 years, and 5(9.6%) of machinist whose works over 10 year, p-value 0.041 (p < 0.05).

The proportion of subjects with subjective health complaints are communication difficulties (24.5%), temporary tinnitus (36.7%), permanent tinnitus (0%), temporary hearing loss (20.4%), permanent hearing loss (0%), emotional disturbances (6.1%), and hypertension (0%). Statistical analysis between work length and hearing loss showed significant association, but between work length and health complaints showed an unsignificant association (p-value >0.05)

1. Introduction
The unwanted noise, which is referred to as noise, including air pollution. Noise at certain levels can be harmful to health, which cause auditory disorders as deafness and tinnitus, as well as non-auditory disorders such as impaired concentration, communication and socialization disorders, sleep disorders, fatigue, stress, hypertension, disorientation, and decreased productivity.¹⁻⁶

The incidence of hearing loss induced by noise (NIHL) and other subjective complaints are high, especially in populations which exposed to high enough noise, especially noise associated with the work environment⁷, such as machinist and assistant machinist who work above a noisy locomotive. Factors that affect the noise induced hearing loss are the intensity, frequency, and duration of noise exposure and also age, gender, individual tolerance, and the application of ear protection devise.¹ Those who has NIHL it will lose the ability to work and decrease quality of life, so that complaints and symptoms of NIHL must be identified early and well-controlled.
In Indonesia, train is one of transportation that most often used by people to travel between cities and remote areas, therefore the health of the machinist and assistant machinist especially the hearing health must be considered, for the sake of the safety of railway passengers. Therefore, research was conducted to know the effect of extended noise exposure to hearing loose and subjective health complaints in machinist and assistant machinist at Bandung.

2. Methods

It was quantitative study with cross sectional design, the dependent variables were the incidence of Noise Induce Hearing Loss (NIHL) of subject that diagnosed by anamnesis and pure tone audiometry examination result which marked by notch on frequency, the other variable dependent were subjective complains induced by extended noise such as emotion disorder, temporary tinnitus, permanent tinnitus, communication disturbance, hypertension, temporary and permanent hearing loss that conclude from validated questioner.

Data’s collected on September- October 2014 at Health Center for crew PT Kereta Api Indonesia, Bandung Station. There was 52 from 55 workers fulfill inclusion and exclusion criteria for analyzed the correlation between work length and hearing function, and only 49 subjects fulfill for analyzed correlation between work length and subjective health complaint, because 6 person not eligible that is 1 person has incomplete data, 2 person has history of ototoxic medication and 3 person has history of former job as employee at noise environment.

All subject was taking anamnesis with validated questionnaire, vital sign and physical examination and further examined by pure tone portable audiometry at adjusted room. Intensity measurement was done for all locomotive that common use at PT Kereta Api Indonesia area 2 (Bandung Station) which are CC201, CC203, CC204, and CC206. Data’s was analyzed by chi square test (p<0.05). This study was approved by Ethical Committee for Research Faculty Medicine Universitas Padjadjaran.

3. Results

Loud intensity of the locomotives was measures by Sounds Lever Meter on CC201, CC203, and CC206 (CC204 was unused). Measurement was done on the 4 corner and at the center of the locomotives.

Table 1. Characteristic of Locomotives’ Loud Intensity

| Locomotives | Mean (dB) | Maximum (dB) | Minimum (dB) |
|-------------|-----------|--------------|--------------|
| CC201       | 85,98(4,061) | 95,2          | 75,3          |
| CC203       | 88,547(11,87) | 118           | 73,9          |
| CC206       | 83,81(4,257) | 91            | 74,1          |

CC201 and CC203 has similar characteristic made booth engine produces not too much different loud intensity. CC206 is the newest locomotive, the engine is smoothest and lowest loud intensity among the other.

Characteristic of 52 research subject was shown on the table 2.
| Characteristic                  | Total (n=52) |
|--------------------------------|--------------|
| Occupation                     |              |
| Machinist                      | 40(76.9%)    |
| Assistant Machinist            | 12(23.1%)    |
| Marital Status                 |              |
| Unmarried                      | 8(15.4%)     |
| Married                        | 44(84.6%)    |
| Age (Year)                     |              |
| Mean(Std. Dev)                 | 36.08(9.464) |
| Median                         | 36           |
| Range                          | 22-54        |
| Height (cm)                    |              |
| Mean(Std. Dev)                 | 168.14(5.851)|
| Median                         | 167.75       |
| Range                          | 158-186      |
| Weight (kg)                    |              |
| Mean(Std. Dev)                 | 66.19(9.628) |
| Median                         | 65           |
| Range                          | 47-85        |
| Noise Protection Device        |              |
| Yes                            | 0(0%)        |
| No                             | 52(100%)     |
| Smoking                        |              |
| Yes                            | 41(78.8%)    |
| No                             | 11(21.2%)    |
| Work duration (Year)           |              |
| Mean(Std. Dev)                 | 14.63(8.397) |
| Median                         | 17           |
| Range                          | 2-32         |

Base on data’s above, it might be concludes that almost all subject as occupation as machinist, in practice, machinist can cover all the job of the assistant, but not vice versa. Base on marital status almost all subject has been married(84.6%) and mean of their age are 36.08 years old + 9.464, erja mean of their height are 168.14 cm + 5.851 and weight 66.19 kg + 9.628. All subject did not use noise protection devise during work, this happen because the device not available and not provide by PT KAI (Kereta Api Indonesia). About 78.8% subject are active smoker and the rest are non-smoker or passive smoker.

Base on table 2, the mean of work duration which calculates from first day of work are 14.63 years + 8.397 with median 17 year and ranges 2-32 year.

Moreover, the work duration divided onto 3 groups are <10 year, 10-19 year, and > 20 year. The results are shown on table 3 below.
Table 3. Characteristic of Subject’s Work Duration

| Work Duration | N   | %   |
|---------------|-----|-----|
| <10 year      | 18  | 34.6|
| 10-19 year    | 24  | 46.2|
| >20 year      | 10  | 19.2|
| Total         | 52  | 100 |

Characteristic subject’s hearing function base on audios copy and audiometry examination was shown on the table 4 below:

Table 4. Characteristic Subject’s Hearing

| Hearing Function | n | % |
|------------------|---|---|
| NIHL             | 11 | 21.2 |
| Unilateral       |   |    |
| Left             | 2 | 3.84|
| Right            | 1 | 1.92|
| Bilateral        | 9 | 17.3|
| Non-NIHL         | 41| 78.8|
| Total            | 52| 100|

NIHL = Noise Induced Hearing Loss

About 21.2% subject has NIHL including 17.3% among them happened on bilateral ear. About 41 subjects (78.8%) are non NIHL including 5 subjects (9.6%) has sensory neural hearing loss and the rest are normal.

The effect of work duration to hearing impairment on the subjects, shows on table 5 below:

Table 5. Correlation Work Duration and Hearing Function

| Work Duration | Hearing Function | Total |
|---------------|------------------|-------|
|               | NIHL             | Non-NIHL | |
|               | (n) | (%) | (n) | (%) |
| <10 year      | 2  | 3.8 | 16 | 30.8 | 18 |
| 10-19 year    | 4  | 7.7 | 20 | 38.5 | 24 |
| >20 year      | 5  | 9.6 | 5  | 9.6  | 10 |
| Total         | 11 | 21.1| 41 | 78.9 | 52 |

P-value = 0.041
CI 95%

From table 5 above shown that there was correlation between work duration and hearing function (p< 0.05).

Meantime, the frequency of subject’s health complains that collected from anamnesis and validated questionnaire are shown on table 6.
Table 6. Frequency of Subjective Health Complains

| Complains                         | Frequency | Proportion (%) |
|-----------------------------------|-----------|----------------|
| Communication inside locomotive   |           |                |
| easy                              | 37        | 75.5           |
| difficult                         | 12        | 24.5           |
| Temporary Tinnitus                |           |                |
| present                           | 18        | 36.7           |
| none                              | 31        | 63.3           |
| Permanent Tinnitus                |           |                |
| present                           | 0         | 0              |
| none                              | 49        | 100            |
| Temporary Hearing Loss            |           |                |
| present                           | 10        | 20.4           |
| none                              | 39        | 79.6           |
| Permanent Hearing Loss            |           |                |
| present                           | 0         | 0              |
| none                              | 49        | 100            |
| Emotional Disturbance             |           |                |
| present                           | 3         | 6.1            |
| none                              | 46        | 93.9           |
| Hypertension                      |           |                |
| present                           | 0         | 0              |
| none                              | 49        | 100            |

Frequency of subjects that has complaints was 32 from 49 subjects (65, 3%) and 17 subjects (34, 7%) has no complaints at all. Frequency of subject whom has one complaint was 19 subjects (38,8%), has 2 complaints was 9 subjects (18,4%), has 3 complaints was 3 subjects (6,1%) and only one subject whom has 4 complaints. Frequency and propulsin of the complains were shown on table 3 above. There were subjective complaints about temporary tinnitus (36, 7%), difficulty on communication inside locomotive (24, 5%), temporary hearing loss less (20, 4%), and emotion disturbance (6, 1%). No one complaint tinnitus, permanent hearing loss or hypertension.

Correlation between work duration and subjective health complaints shown on table 7 below:
Table 7. Correlation Work Duration and Subjective Health Complaint

| Subjective Health Complaint | Present | None | p  |
|-----------------------------|---------|------|----|
|                             | n       | %    | n  | %     |    |
| Communication Difficulty    |         |      |    |       |    |
| ≥10 year                    | 6       | 21,4 | 22 | 78,6  | 0,565 |
| <10 year                    | 6       | 28,6 | 15 | 71,4  |    |
| Temporary Tinnitus          |         |      |    |       |    |
| ≥10 year                    | 9       | 32,1 | 19 | 67,9  | 0,441 |
| <10 year                    | 9       | 42,9 | 12 | 57,1  |    |
| Permanent Tinnitus          |         |      |    |       |    |
| ≥10 year                    | 0       | 0    | 28 | 100   | -    |
| <10 year                    | 0       | 0    | 21 | 100   |    |
| Temporary Hearing Loss      |         |      |    |       |    |
| ≥10 year                    | 8       | 28,6 | 20 | 71,4  | 0,155 |
| <10 year                    | 2       | 9,5  | 19 | 90,5  |    |
| Permanent Hearing Loss      |         |      |    |       |    |
| ≥10 year                    | 0       | 0    | 28 | 100   | -    |
| <10 year                    | 0       | 0    | 21 | 100   |    |
| Emotional Disturbance       |         |      |    |       |    |
| ≥10 year                    | 0       | 0    | 28 | 100   | 0,072 |
| <10 year                    | 0       | 14,3 | 18 | 85,7  |    |
| Hipertension                |         |      |    |       |    |
| ≥10 year                    | 0       | 0    | 28 | 100   | -    |
| <10 year                    | 0       | 0    | 21 | 100   |    |

Base on statistical analysis on table 7, there was no significant effect of work duration to subjective health complaints.

4. Discussion

Noise intensity level from Sound Level Meter on all locomotive PT KAI area 2 Bandung were recorded high. It is exceeding the safety limit noise exposure that stated by WHO (85 dB). This can be huge risk for machinist and his assistant who working on it for health impairment especially for hearing dysfunction. Furthermore, all the subject (100%) did not apply noise protection device while they worked, it is added more risk for NIHL incident on machinists and his assistant. The reality from data that most of the subject are active smoker, also aggravate risk for NIHL, its consistent with research by Saber Mohammadi that NIHL risk 9.06 times higher on smoker than non-smoker.  

NIHL is sensor neural type of hearing disorder characterized by the dip in the frequency 4 kHz. Extended noise exposure can lead mechanical and metabolic damage. Mechanically, on sound with intensity 115-125 dB, will be marked lot of damages on Reissner membrane, basilar is, inner and outer hair sel, damage, streosilia, and intracellular organelle such as reticulum endoplasmic. Sound with intensity less than 115 dB can lead to ischemic reperfusion on cochlea that will produces Reactive Oxygen Species(ROS), ROS will activated stress-kinase cell-death pathway such as MAPK that involved JNK and c-Jun. JNK will activated proapotic BH-3 that can cause inner and membrane of mitochondria produces cytochrome c into cytoplasm. Inside cytoplasm, cytochrome c will invade to apoptosis and activated caspase-9 and capcase-3 than can lead membrane lipid, protein, and DNA damage, and will cause cell death and demise
sel and changes in hearing threshold.\textsuperscript{4, 7, 9, and 18} this is consistent with this study that there was correlation between extended noise exposure and hearing loss (NIHL) (p<0.005).

From anamnesis on 49 subjects in this study, it was found subjective health complaints on the subjects such as communication difficulty (24, 5%), temporary tinnitus, tinnitus (36, 73%), temporary hearing loss (20, 41%), and emotional disturbance (6, 12%). Other complaints was permanent tinnitus, permanent hearing loss and emotional disturbance were not recorded from all subjects. It is consistent with previous study by Ike Pujiriani (2008) at Jakarta shown that 47,9% machinists was complained subjective health complaint such as annoying feeling because of noisy, communication difficulty, differences in hearing sensitivity.\textsuperscript{10} On factory workers at Bandung, 43 from 109 employee (39,45%) has subjective complaint such as clogged ear, discharge from ear, hearing loss, and intermittent tinnitus, about 41% suffered NIHL.\textsuperscript{11} Previous study on electronic factory by Hardini Tjan (2013) found 29 subjects (85,3 %) has subjective complaints which is the most common are chronic malaise, headache and tinnitus.\textsuperscript{7} Even though in this study there was present of subjective complaints, but based on statistical analysis found that there was not significant correlation between work duration and subjective health complaints (p>0.05). This result was contradict with common assumption that longer noise exposure on worker in noisy environment more subjective health complaints can generates. Previous study by Agus Sulistianto (2009) on machinist at Semarang shown there was correlation between work period and NIHL (p-value 0,01), whereas incidence of NIHL happen more on machinist with work duration > 10 years.\textsuperscript{14} Study by Tri Budiyanto on textile factory Yogyakarta (2010) concludes that significant correlation between work duration and stress incident (p-value 0,019).\textsuperscript{15} Other study on rock musician conclude that there was significant correlation between work duration and non-auditory disturbance (p-value 0,028).\textsuperscript{16} The different result of this study with other previous studies might be caused by abnormal distribution of work duration on the subjects and wide range that is 26 year, it is might be less describe the real condition of population. Result of previous study by Bluhm (2007) shown that was correlation between noise exposure and hypertension incident but this result still speculative and need further investigation.\textsuperscript{17}

5. Conclusion

Conclusion of this study are extended noise exposure effect to health impairment especially hearing dysfunction. There was correlation between work duration on NIHL incident (p<0.05), but not on subjective health complaints such as communication difficulty inside locomotive, temporary tinnitus, temporary hearing loss and emotional disturbance on machinist and machinist assistants PT Kereta Api Indonesia (PT KAI) operational area 2 Bandung.

Limitation of this study are there was not analyzed confounding factors such as smoking and noise exposure from outside work environment. Previous study from Mohammadi (2010) concludes smoking can accelerates NIHL incident on workers, although this statement need further investigation.\textsuperscript{21} Other limitation of this study are non-randomized data collection, so the result cannot described real population condition. This is evident also from the data are not normally distributed so poorly in representing the state of the population. Suggested for further research by increasing the number of samples for normal data distribution.

It is also suggested for further research can be done in a cohort, anamnesis, physical examination and audiometry should be done regularly since a recruitment, so it could be describe with the time pattern of any health complaint especially hearing dysfunction on machinists and assistant machinists. Population of study can be expanded to all workers on train station who also exposed by the loud noise of the train every day.

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