Hearing Loss Risk Factors among Gold Mining Dozer Operators

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ABSTRACT

Introduction: Industrial mining activities have the highest prevalence of NIHL due to the operation of a heavy vehicle. Dozer is one of the heavy vehicles with a high noise level. This study aims to analyze the hearing loss risk factors in dozer operators. **Methods:** This study was analytical descriptive research about risk factors related to hearing loss of 28 dozer operators at Gold Mining Company. The risk factors consisted of demographic factors, working behavior (listening to music and smoking), and noise levels which were analyzed with hearing loss using STS. The company representatives further also conducted interviews and tests with the workers. Hearing loss examination was done by using an audiometric test to determine the STS of the operators with the positive result of more than 10 dB and negative at 10 dB or less. All the data involved are secondary data. **Results:** Noise level of all dozers exceeds the TLV (>85 dB) operated for 10 hours a day and six days a week. Half of the dozer operators had STS (+) which occurred at the age of 40 years olf and older, working for more than five years, did not use or misused the Personal protective equipment (PPE), as well as having the habit of listening to music and smoking. **Conclusion:** Noise and demographic factors can increase the risk of hearing loss in dozer operators.

Keywords: dozer operators, hearing loss, mining, noise

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INTRODUCTION

Noise can arise due to activities or production processes in a company (Ramadhani and Firdausiana, 2020). Noise can be harmful when it is too loud, even for a brief time, or when is it too loud and has long-term exposure (Sliwinska-Kowalska and Davis, 2012). The impact of noise on the human hearing organ depends on several factors such as the volume of sound, noise's characters, duration of exposure, and individual susceptibility (Dudarewicz *et al.*, 2018). Noise can cause noise-induced hearing loss either temporary or permanent, depends on the intensity and duration of the noise exposure (Cunningham and Tucci, 2017). Hearing loss is defined as the worsening of hearing acuity and is usually expressed as an increase of hearing threshold (Śliwińska-Kowalska and Zaborowski, 2017).

Hearing plays an important role in daily activities such as communication, health function, work, and quality of life (Blackwell, Lucas, and Clarke, 2014). Noise can induce hearing loss. The prevalence of hearing loss is associated with low employment rates, lower worker productivity, and high health care costs. Furthermore, adults with hearing loss are more likely to have low income and be unemployed or underemployed than adults with normal hearing (National Academies of Sciences, Engineering, and Medicine, 2016). In addition, hearing loss is also the fourth highest cause of disability globally, with an estimated annual cost of over 750 billion dollars (World Health Organization, 2018).

Hearing loss is one of the most common work-related illnesses in United States(Levin *et al.*, 2016). Noise-Induced Hearing Loss (NIHL) is irreversible and reported as occupational injury being the most common cause of sensorineural hearing loss. Thirty million workers in the United States were at risk of NIHL, with the most ages being at 20-69 years old (Yin *et al.*, 2020). Rates of hearing loss have increased globally every year and predicted to be increased until 2050 (World Health Organization, 2018).

Hearing loss can be caused by several factors. Previous study stated that hearing loss risk factors

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include noise intensity, duration of exposure, work period, individual susceptibility, and sustainability of hearing conservation program (Wiradewa, Wiyadi and Dewanti, 2017). Other previous study showed that risk factors that affect the severity of hearing loss are noise intensity, frequency, length of exposure per day, work period, individual sensitivity, age, and other factors that can cause deafness (Mayasari and Khairunnisa, 2017; Septiana and Widowati, 2017; Abraham *et al.*, 2019).

According to previous studies, the highest prevalence of NIHL is in the mining sector (61%), followed by the construction sector (51%), the manufacture sector (47%), the utilities sector (43%), and the transportation sector (40%) (Abbasi, 2018; Kerns *et al.*, 2018). The mining sector has the highest prevalence of Noise-Induced Hearing Loss because its activities use heavy vehicles, causing noise from vibrating machines (Abbasi, 2018). One of them is a dozer with a noise intensity level of more than 85 dB which is consistent with the results of preliminary observations in one of the gold mining companies in Indonesia (Tong *et al.*, 2019). The average noise level of the dozer was above 90 dB with 10 hours of work per day. It has exceeded the regulations, since the daily noise level exposure allowed for the workers is 85 dB for 8 hours per day and or 40 hours per week (Minister of Manpower Regulation, 2018).

Noise is a physical hazard factor that can affect human performance and cause NIHL. The NIHL arises because the sound received has exceeded the threshold of human hearing. The threshold for noise-induced hearing loss first appears at high frequencies. The maximum range of sound that humans can accept reaches 20,000 Hz (Majidpour *et al.*, 2021). Prolonged (long or repeated) exposure to noise at or above 85 dB can cause hearing loss (Yin *et al.*, 2020).

Based on some previous studies, hearing loss measurements have been made on heavy vehicle operators in mining. However, it has not yet explicitly explained the picture of hearing loss in dozer operators, instead it only described noise levels (Saleh, Woskie and Bello, 2017). This research focused on the hearing loss of dozer operators in the mining sector in one of the gold mining company in Indonesia. Based on preliminary surveys conducted at and by Gold Mining Company, many dozer operators experienced uncomfortable complaints because of the noise received while operating the dozer unit. The previous study stated that worker with hearing loss had experienced such as decreased concentration, fatigue, headaches, sleep disturbances, and loss of job so that company need to prevent the hearing loss (Setyawan, 2021). Besides, data gathered revealed that 50% of operators experienced hearing loss based on company health data using the Standard Threshold Shift (STS). The purpose of this study was to analyze the risk factors for hearing loss in dozer operators in this gold mining company. Therefore, the risk factors of hearing loss among dozer operators can be identified, and company can determine the corrective action to reduce the prevalence of hearing loss among the dozer operators.

METHODS

This study was analytical descriptive research and was conducted at Gold Mining Company (one of the gold mining companies in Indonesia) on 28 dozer operators in 2019. The noise intensity of each dozer and operator's Standard Threshold Shift (STS) data were obtained from the company's annual report. The research instrument used is the Sound Level Meter which has been calibrated regularly. This instrument is a tool to measures the noise between 30 - 130 dB with a frequency of 20 -20000 hertz. The company representatives also conducted interviews with workers to get the data related to operator demographic factors, compliance using Personal Protective Equipment (PPE) and habit of listening to music and smoking on dozer operators.

Standard Threshold Shift (STS) indicates visible and vital changes in hearing threshold over the years. STS is one of early screening method that can detect indications of hearing loss (World Health Organization, 2018). The dozer operator STS was measured by audiometric test. At the same time, the STS is a program to find out changes in the mean that are worse than 10 dB or exceed 2000, 3000, 4000 hertz frequencies relative to the baseline. The baseline is the first hearing test or audiogram obtained when entering a hearing conservation program. Each annual audiogram was compared with the reference baseline to identify significant developments. If the operator experiences hearing loss, the STS is positive (+) if it greater than 10 dB, while the operator who does not experience hearing loss is STS negative (-) at 10 dB or less. All data were collected from The Gold Mining Company, then inputed and analyzed using Microsoft Excel and data analysis software.

RESULT

Gold Mining Company is one of the gold mining companies in Indonesia which operates four dozer units. The types are D8R 3017, D155A 3001, D85-SS 2011, and D85-SS 2012. Figure 1 and 2 are examples of dozer machine operated in project area of Gold Mining Company.

In this case, the other dozer pictures are not documented. In daily practice, each dozer operates for 10 hours per day and six days a week. All dozer operated by the operator in Gold Mining Company.

Dozer Noise Levels

The following is the dozer noise levels that operates in Gold Mining Company. Based on figure 3, data obtained from the dozer engine noise at Gold Mining Company totalling 4 units showed the lowest noise intensity was 90.03 dB and the highest was 106.28 dB, with an average of 98.99 dB.

Hearing Loss Among Dozer Operators

The following is the prevalence of hearing loss of dozer operators in Gold Mining Company.

Figure 1. Dozer Komatsu Type D85-SS

Figure 2. Dozer Komatsu Type D155A

According to figure 4 shows that 28 dozer operators surveyed in Gold Mining Company who experienced STS (+) were 14 people (50%) and STS (-) as many as 14 people (50%). This study analyzed the dozer operators who experience STS (+) more deeply based on the demographic factors and noise levels.

Hearing Loss by Noise Levels

The following is the prevalence of hearing by noise levels of dozer operators in Gold Mining Company. Table 1 described the distribution of STS + in each dozer. In this case, two people in dozer A (90.03 dB) experienced STS (+), three people in dozer B (94.23 dB) experienced STS (+), four people in dozer C (105.42 dB) experienced STS (+), and five people in dozer D (106.28 dB) experienced STS (+). Tabel 1 shows that most dozer operators experienced STS (+) are those who operate the type of dozer D85-SS 2012 which makes high intensity sound of 106.28 dB. Based on data in Tabel 1, the higher sound or noise level of dozer engine, the more operators experienced the STS (+).

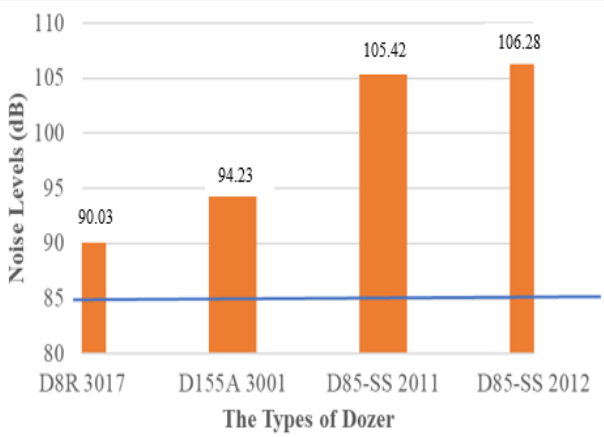

Figure 3. The Dozer Noise Levels in Gold Mining Company

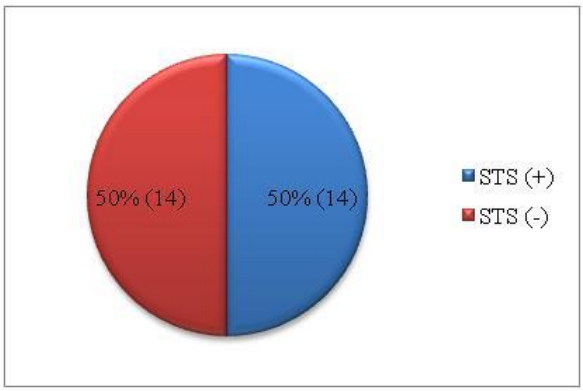

Figure 4. Prevalence of Hearing Loss among Dozer Operator

Hearing Loss and Demographic Factors

The following is the prevalence of hearing loss by demographic factors (age, work period, Personal Protective Equipment (PPE), music listening and smoking habit) of dozer operators in Gold Mining Company:

Table 2 showed the distribution of 14 dozer operators who experienced STS (+). There were 11 out of 14 STS (+) aged 40 years or older. Most operators who experienced STS + were at the age of 40 years or older. There were three people (21.43%) working for less than five years, and 11 people (78.57%) who had been working for five years or more. STS (+) was also experienced by operators who worked using PPE with 12 out of 14 people (85.71%). Two operators did not use PPE correctly and experienced STS +. Moreover, there were 4 of 14 people (28.57%) who experienced STS (+) in operators accustomed to listening to music, while the remaining 10 people (71.43%) in operators not accustomed to listening to music. Four workers often listened to music and experience STS +. Thirteen workers smoked and experienced STS (+) (92.86%) and one person (7.14%) who were not.

Table 1. Prevalence of Hearing Loss by Noise Levels of Dozer Operators in Gold Mining Company, 2019

Type of Dozer	Noise Levels (dB)	STS (+)
D8R 3017	90.03	2
D155A 3001	94.23	3
D85-SS 2011	105.42	4
D85-SS 2012	106.28	5
Total		14

Table 2. The Data of Hearing Loss by Demographic Factors of Dozer Operators in Gold Mining Company, 2019

Demographic Factors	STS (+)	Percentage (%)
Age (years)		
< 40	3	21.43
≥ 40	11	78.57
Work Period (years)		
< 5	3	21.43
≥ 5	11	78.57
Use of PPE		
Yes	12	85.71
No	2	14.29
Music Listening Habit		
Yes	4	28.57
No	10	71.43
Smoking Habit		
Yes	13	92.86
No	1	7.14

DISCUSSION

Dozer Noise Levels

Data of noise measurement on four dozer units showed that the intensity of the engine noise was above the threshold value. The lowest noise level of the dozer is 90.03 dB and the highest one is 106.28 dB. According to group of decibels that caused by several noise sources, dozer is one of the group motorcycles and dirt bikes that make sound or noise between 80 – 110 decibels (dB) (Sliwinska-Kowalska and Davis, 2012).

The permissible provision for a person to work in a noisy room or workplace is 85 dB for eight hours per day or for 40 hours per week (ACGIH, 2020). The operators carry out the job for 10 hours a day and six days a week. Number of working hours in a week is 60 hours. It means that the working hours of the operators exceeds the policy and not in accordance to the regulation either in Indonesia or globally (Minister of Manpower Regulation, 2018; ACGIH, 2020). If the dozer machine operator does the job and over-exposed to noise above the threshold value, it will potentially decrease their hearing ability (hearing loss).

Company can protect workers against any occupational hearing loss by controlling the noise exposure in the workplace. It will be much better if workers exposed to noise for 8 hours with exposure limit of 75 dB(A). However, even this lower limit assumes that workers will not be exposed to additional loud noise from household chores and repairs, hobbies such as listening to the loud music, urban environments, and others. the U.S. Environmental Protection Agency (EPA) asserted that sound levels up to 70 dB(A) represent a safe "effective quiet" that poses little risk to people with normal hearing because they do not induce significant temporary audiometric threshold shifts (Pienkowski, 2017).

Hearing Loss and Noise Levels

Based on figure 1 in the results, the noise intensity of the entire dozer engine exceeds the Time Limited Value (TLV) (85 dB) and operates more than 8 hours per day and or 40 hours per week (Peraturan Menteri Ketenagakerjaan, 2018; ACGIH, 2019). The operator ran the dozers for 10 hours per day with noise intensity exceeding Threshold Limit Value (TLV). According to regulation, dozer A (90.03 dB) allowed to operate per day was for 2 hours 31 minutes, dozer B (94.23 dB) for 1 hour per day, dozer C (105.42 dB) for 4 minutes 43 seconds per day, and dozer D (106, 28 dB) for 3 minutes 43 seconds per day (Peraturan Menteri Ketenagakerjaan, 2018; ACGIH, 2019).

Based on Table 1, data obtained depicted higher noise intensity causing a higher risk of operators experiencing hearing loss (Setyawan, 2021). Loud sounds possibly damage the cochlea hair cells in the ear (Waqas *et al.*, 2018). The damaged of hair cells in mammalian can cause a permanent NIHL, it means that it cannot regenerate (Le *et al.*, 2017). Recent studies had shown that hearing loss can occur when inner hair cells synapse with spiral ganglion cells and following by noise exposure (Waqas *et al.*, 2018).

Noise level can produces changes to the cilia hair cells of the corti organs. Stimulation with moderate sound intensity can contribute for mild changes in the sillia and Hensen's body, whereas high-intensity stimulation during long exposure times would make damage to other hair cell structures such as mitochondria, lysosome granules, cell lysis and tearing of the tympani membrane. The first affected areas are external hair cells, which show an increased degeneration with the intensity and duration of exposure. Stereocilia on the outer hair cells becomes less rigid, thereby reducing a response to stimulation (Setyawan, 2021).

Hearing Loss and Demographic Factors

Most operators who experienced STS + were at age of 40 years or older. Age is an individual susceptibility that can affect the occurrence of hearing loss (Yin *et al.*, 2020). In this case, the age of 40 years is when human vulnerable to trauma due to noise (Setyawan, 2021). Based on a cross-sectional study on metal companies in Rio de Janeiro, Brazil, a significant increase in the hearing loss prevalence was directly proportional to the rise in age (Setyawan, 2021).

The previous research that obtained in United States shows that the prevalence of hearing loss doubles with every 10-year increase in age. It means that the older dozer operators, the more potential to experience hearing loss (Cunningham and Tucci, 2017).

Most operators experiencing STS (+) had worked at least for five years. A cross-sectional study on metal companies in Rio de Janeiro, Brazil, found a significantly increased hearing loss prevalence was directly proportional to an increase in work period (Setyawan, 2021).

The previous research showed that the longer work period more potential to experience hearing loss than the new one. The workers who have 10 years work period or more tend to have higher hearing threshold than workers with less than 10 years of work period (Wiradewa, Wiyadi and Dewanti, 2017). Other research showed that workers who work more than 10 years are having a risk of Noise Induced Hearing Loss 3.656 times greater than workers who work 10 years or less to experience Noise-Induced Hearing Loss (Septiana and Widowati, 2017).

The longer work period of dozer operators, the higher potential they have to get hearing loss (Ramadhani and Firdausiana, 2020). Effect of noise exposure could rise after five years or more of working period. It will be worse if the noise exposure prolonged or continue year by year (more than 10 years of work period). The hearing loss can be a permanent hearing disorder (Harrianto, 2013). Approximately 78% of the healthy years lost were attributable to mild or moderate hearing impairment. Preventing any occupational hearing loss is the best way to reduce worker hearing impairment over a lifetime, because even mild-to-moderate impairment during working years can culminate in more healthy years lost during retirement (Masterson *et al.*, 2016).

A hearing threshold shift related to intense noise exposure is occasionally temporary in its initial stages and is manifested as Temporary Threshold Shift (TTS). TTS may become permanent (Permanent Threshold Shift—PTS), due to repeated, chronic noise exposure, and/or due to a single exposure to intense noise (Śliwińska-Kowalska and Zaborowski, 2017).

Two operators did not use PPE correctly and experienced STS +. PPE is the primary protection tool in the prevention of hearing loss. Therefore, hearing loss events are strongly influenced by

the use of PPE in high-noise work environments. Based on observations, these workers did not use PPE correctly and adequately, and it caused the occurrence of hearing loss. The operators compliance in using PPE was influenced by a set of factors related to the individual, organizational and cultural systems, management, law and regulations, work organization, and PPE specification (Tinocco, *et al.*, 2019). Based on observations and interviews conducted by the company representatives, the company had provided PPE in the form of earplugs for every operator. According to the PPE manual book, the earplug can reduce 33 dB in proper usage and can reduce 13 dB if the usage is not ideal. It can be underlined that workers need to use the hearing protection equipment in proper way and fit well to reduce noise exposure effectively (Carroll, *et al*, 2017).

Using the personal protection equipment or PPE can avoid the exposure of noise that too loud in the environments or workplace. It will be effective by using of personal hearing protection devices such as earplugs or earmuffs. Studies have been shown to prevent hearing loss (Themann, Suter, and Stephenson, 2013).

Four workers often listened to music and experience STS (+). The results of interviews obtained that the sound level of music dozer operators was as the volume of ¾ to full volume (high). According to previous study, turning the volume up to maximum volume could make noise between 94 – 110 dB (Sliwinska-Kowalska and Davis, 2012).

Listening to music at high volumes, especially with headphones, was a common cause of hearing loss. The degree of a hearing loss was related to the level of the noise and the duration of the exposure (Yin *et al.*, 2020). Ten operators experiencing hearing loss STS (+) might be influenced by the duration of the use of headsets or earphones. According to WHO, the maximum time limit for someone listening to music using headsets or earphones is 4 hours 20 minutes in 7 days (World Health Organization, 2018; World Health Organization, 2015).

There are 10 workers who have the habit of listening to music but have STS (-), according to previous research. If these workers do not experience hearing loss, then at least they have hypertension and cholesterol (Kerns *et al.*, 2018). Duration of listening to the music will be safe for 2 hours at intensity of 91 dB, 15 minutes at intensity of 100 dB, while for 103 dB only some 7 minutes a day (Swierczek, Sochan and Kornatowska, 2020).

Music and noise levels are loud enough to permanently damage the ear, although it causes comfortable and even addicting enjoyable. Somebody with hobby such as listening to music with earphone or others seems likely exposed repeatedly to loud music and leisure noise is a major reason to experience the increase of hearing loss. The high rates of exposure through this source made somebody feel enjoy. Thus, it will make the person repeat that way (Welch and Fremaux, 2017). Other research stated that a loud music and noise exposure outside the work environment exacerbates the risk of occupational hearing loss (Feder *et al.*, 2017).

Thirteen workers smoked and experienced STS (+) because smoking activities with noise exposure had a synergistic contribution to increase NIHL. Previous studies mentioned that cigarette smoking could cause NIHL with ototoxic effects of carbon monoxide (Themann and Masterson, 2019; Li *et al.*, 2020). One worker who did not smoke but experienced STS (+) is an operator who had worked for five years or more and did not use PPE properly.

Noise control can be carried out at the source, transmission, and receiver (Claudia, Valentin and Gabriel, 2011). Handling noise source from engine dozer with conducting an inspection such substitute an old machine with a new one even caused high cost. Control on the media in dozer cab is with attaching damper between the source and the receiver noise to reduce the noise that enters the cabin. Combining plywood, foam, tray, and coir material can reduce by 31.94 dB. It also can treat and repair damage to the dozer parts by tightening loose bolts throughout the dozer cabin and repairing rubber coatings on windows, doors, ceilings and other components with hollow or not tight.

Preventing hearing loss will be effective by reducing the noise from the dozer engine using various fibrous materials including inorganic and metallic fibers, synthetic fibers, natural fibers, and nanofibrous membranes for noise reduction. Inorganic and metallic fibers have the advantages of corrosion resistance, high temperature resistance and durable installation (Tang and Yan, 2017a ; Tang and Yan, 2017b).

Control on the receiver can be set administratively by work shifts. Besides that, if the dozer operator uses the earplug correctly, it can reduce the noise level exposure by 33 dB, while

improper usage can only decrease by 13 dB. All that can be done to reduce the negative effect of the noise effectively is application of hierarchy of control (Murphy *et al.*, 2020).

Besides, PPE usage in both earmuff and earplug can reduce noise to below the TLV or by combining both (double protection). According to Occupational Safety and Health Administration (OSHA), at very high levels of the noise intensity, employees should use ear-protection through dual-use, which are earmuff and earplug that will be work simultaneously in decreasing the noise (Occupational Safety and Health Administration, 2002).

Double protection PPE can reduce exposure to noise levels by 38 dB on correct use, while improper use can only reduce 18 dB. However, with a note that the calculation is not the sum between Noise Reduction Rating (NRR) earplug and NRR earmuff, but the highest NRR value is added by 5 (National Safety Council, 2019).

CONCLUSION

The conclusion of this study indicated that higher noise intensity might cause higher risk of operators experiencing hearing loss. Dozer operators at risk of hearing loss were at the age of 40 years or older, had worked for five years or more, and did not use PPE properly. These operators had a habit of listening to music and smoking. Based on this research, the fact that individual awareness factors strongly influenced hearing loss in using personal protective equipment (PPE) and the duration of headphones usage in listening to music.

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