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Original Research Paper

A Noise Pollution Survey in an Iranian Tobacco Products Company

Mohammad Reza Monazzam*, Hamid Shiri, Samaneh Momen Bellah Fard***, Zeinab Baroonizadeh***
***Deptt. of Occupational Hygiene, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
****Deptt. of Ergonomics, University of Social Welfare and Rehabilitation Science, Tehran, Iran
***Deptt. of Environmental Science, Graduate School of the Environment and Energy, Science and Research Branch, Islamic Azad University, Tehran, Iran

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ABSTRACT

Noise as one the important hazardous factors in workplace, which can lead to health injury, decrease in safety and efficiency and financial loss for companies and factories. To control noise in a specific industry, awareness of its sound characteristics such as environmental sound level, worker's exposures level and noise frequency distribution is substantial at different stations. The aim of this research is to describe the sound characteristics of equipments, and to investigate the sound exposure level of workers in Tobacco industry. Within this context, environmental noise and frequency analysis in five main parts of the plant were measured. Based on ISO: 9612 standards, the A-weighted sound pressure level was measured in 565 stations using CEL-257 sound level meter. According to ACGIH guideline noise, areas were divided into three groups including safe area, caution area and danger area. Noise analysis in one octave band and computation of the workers' exposure level of 8 hours were performed in 21 points of danger areas (>85dBA). The maximum and minimum sound pressure levels were in cigarette workplace 2(b) with 95.5 dB (A) and in cigarette workplace 4 with 68.2 dB (A) respectively. Correlation test between environmental sound levels and 8 hours noise exposure indicates their high relation (sign: 0.000. Pearson co: 0.944). Frequency analysis results have shown that most sound levels were at frequency 500 to 2 KHz and in most measurement points, sound level was high at frequency 4 KHz in which makes the PTS risk subsequently.

INTRODUCTION

Noise as the broadest physical threat of workers' health is one of the hazardous factors in workplace (Golmohammadi & Oliyaie 2008, Patel & Ingle 2008). Impacts on human health, work-related accidents and decrease in efficiency due to noise were referred in various studies. Temporary threshold shift (TTS), permanent threshold shift (PTS), acoustic trauma and tinnitus as the auditory system injuries are well known (Golmohammadi 2007, Mato & Mufuruki 1999). Hearing loss or hearing impairment is defined as the change (increase) in the threshold of hearing at a given frequency (Barron 2003). Those noises that make maximum energies at frequencies below about 250 Hz will produce less TTS than noises with maximum energies at frequencies above about 2000 Hz (Barron 2003). The nervous, visual and equilibrium systems as well as auditory system are affected by noise impacts. Interference with speech, occurred at frequencies 100 or 4000 Hz, can lead to an incorrect understanding of messages and occupational disasters (Golmohammadi 2007). According to previous studies (Girard et al. 2009, Picard et al. 2008), exposure to noisy environment with Leq 8hr 90 dB is associated with a higher relative risk of accident. They found that the severity of hearing impairment increases the risk of multiple events three times higher than normal people when the threshold levels exceed 15 dB. Chronic exposure with high sound level is related to cardiovascular disease risks (Davies et al. 2009). Furthermore, epidemiological studies have shown that there is a connection between environmental noise exposure and high blood pressure in elderly and middle aged people (Ni et al. 2007).

Occupational health problems of tobacco during harvesting (Ghosh et al. 1986) and effect of tobacco use on smokers and non smokers (Collishaw et al. 1984) were mentioned from earlier studies where the total number of attributable tobacco deaths is predicted to increase from 5.4 million in 2004 to 8.3 million in 2030 (Schmidt et al. 2010). Meanwhile, the excessive sound due to applied devices in tobacco industry is another negative aspect that could make serious health consequences on workers.

Thus, based on the above issues, it is necessary to pay attention to noise subject more than before. This is more important in developing countries, as there are still several industries with higher levels of SPL than standard values, as a result of which industrial workers and employees become involved with some problems. Thus, the main goal of this study is to predict the current problems in tobacco industry by investigating the environmental noise level and characteristics of the present sound.

The supporting aims of this research could be summarized as; survey on noise risk and excessive noise level relating to threshold limit value of ACGIH (American Conferences on Governmental Hygienists), determination of noise characteristics in each workplace, calculation of noise exposure for predicting the future problems, data collection for control approaches and future researches.

MATERIALS AND METHODS

In this descriptive survey, to investigate and predict an Iranian tobacco factory noise, the sound level of 5 workshops including four cigarette producing workshops along with a packaging workshop, were measured and frequency analysis were performed according to ISO: 9612 standard method. Cigarette producing workshops consist of cigarette workshop 1, cigarette workshop 4, cigarette workshop 2(a), cigarette workshop 2(b) and packaging unit. Totally 680 workers are working in these workshops of which the most workers are in packaging section (210 subject). In addition to workers, white collar employees, managers, inspectors and carrying section employees are exposed to workshop noise. All workers, who work in workshops, should operate in a 10 hours shift work during 7.30 a.m. to 5.30 p.m.

At first, from the noise viewpoint, the risky areas were defined by a primary assessment and then to determine the noise exposure level of workers, the equivalent sound level L_{eq} were measured in the working place stations, the rest rooms of each workshop and dining hall. Finally, survey on the sound characteristics of workshops by frequency analysis of risky areas, as an important factor in further noise control researches, were performed. There are various methods for noise measurement each of which is used for a special goal. For instance, to determine the main source of noise, the sound level difference is used or to determine the noise exposure of workers dosimeter, as the most appropriate method, is applied (Golmohammadi 2007).

According to the aim of this study (environmental noise and workers' noise exposure), and on the basis of ACGIH standard, the network method was used. In this method, workshop is divided into checkered areas with same dimensions. The dimension of these areas depends on number of noise sources, workshop size, noise variations, etc., in which could be ranged from 2×2 squares to squares with 5×5 dimension (m). In this classification, noise areas with SPL below 75 dB are known as the safe area with green colour, areas with SPL between 75 dB and 85 dB are known as the caution area with yellow colour and areas with SPL higher than 85 dB are known as the danger area with red colour. After preparing the plan of each workshop and calculating the areas, stations were organized. To make a precise survey, it was attempted to increase the number of stations as much as possible. Workshop size, survey accuracy, work force and agreement with standards are the factors that were considered to determine the dimensions, and number of stations were according to these issues; 3×3 m was elected. By designing each workshop plan and numbering them, sound measurements were performed. The measurements were performed by the CEL 257sound level meter in which the meter was calibrated by the B&K 4231 acoustic calibrator. Generally, as the A-weighted network is more related to perceived threshold of human ear, the measurements of workers' exposure level are conducted in this network. Totally from 565 SPL measurement stations, the maximum and minimum number of stations were in cigarette workshop number 4 by 138 stations and in cigarette workshop 2(b) by 60 stations respectively. To prepare the isosonic for each workshop, the level of deviation from standard values was first calculated and then according to the above classification a risk level is assigned at each station (Table 1). In the next stage, noise exposure of workers as well as determination of danger areas was studied. Hence, the equivalent sound levels were measured at areas with human activity, rest rooms of each workshop and dining hall of the factory. Based on ISO: 9612 standard, workers' sound exposure of 10 hours was calculated by:

$$Leq_{10hr}(dB) = 10\log\left[\frac{n}{tr}\sum_{i=1}^{n} t_i 10^{\frac{Lpi}{10}}\right] \quad ...(1)$$

Where leq is equivalent sound level, *ti* and *tr* are the duration of noise exposure for *i* (h) and the reference time (8 hours) respectively. *LPi* is the sound pressure level of *i(dB).* From the following equation, the values were changed to the equivalent sound level of 8 hours:

$$Leq_{8hr} = L_p + \frac{10\log 10}{8} \quad ...(2)$$

It should be mentioned that cigarette workshops number one and four, which are newer than the other workshops, have their own packaging unit. To determine the noise characteristics of each workshop, frequency analysis were performed at points with SPL higher than 85 dB at one octave band centre frequencies over the range 63-8000 Hz. Totally, from five workshops 21 points were analysed using the mentioned method.

RESULTS

In the present survey, five workshops were studied in which 680 workers were working per shift. The workers are in the 20-62 age range where most of the workers (50%) are aged below 30 years. Packaging unit and cigarette workshop 2(b) with 210 and 56 personnel have the highest and lowest

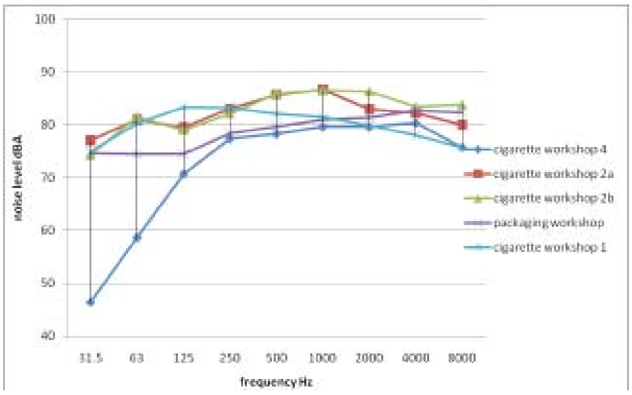

Fig. 1: Comparison of mean noise levels at one octave band.

number of workers respectively. The workers have one hour rest time for two working hours and one hour for their lunch and worship agreeably. To determine the noise risk in the factory, SPL of 565 stations were measured in A-weighted network in which the highest SPL was found in cigarette workshop 2(b) near to Hauney cigarette production set with 95.5 dB (A), and the lowest SPL was seen among stored box in temporary warehouse of cigarette workshop 4 by 68.2 dB(A). The measured levels are related to operation sections of workplace where the subjects are moving or begin to stop. There was no safe area among the cigarette workshop 2(a), (b) and packaging workshop and only four stations through 565 stations have safe area. Most caution areas were in cigarette workshop 1 in which 93.3 percent of the stations of this workshop were involved. Cigarette workshop 2(b) has the most danger areas where 96.8 percent of its stations were included in danger area. Building materials used in various workshops were different of which floor and walls of cigarette workshop 1 were covered with epoxy and belka respectively. Mosaic floor and plaster wall were seen in cigarette workshop 2(a) and 2(b) and also in packaging workshop. In cigarette workshop 4, tiles were laid on the floor and plaster was stuck on the walls. With regard to reflection, surfaces of cigarette workshop 1 have the best condition at which the applied materials have less reflection. Some parts of cigarette workshop 2 are allocated to out of date devices. These devices with their uncovered metal surface could be a noise reflection source for other tools. Although, considering the temperature and environmental conditions, the new ventilation system of cigarette workshops number 1 and 4 makes a satisfactory circumstance; its noise pollution is considered as a negative factor. Table 1 shows the results of environmental measurements in workplace. The number of stations and risk ranking of noise are shown for each workshop separately.

As indication of danger stations for measuring workers' noise exposure during shift work was not sufficient, equivalent exposure level (Leq 8 hours) was computed. While dosimetry is more appropriate for this purpose, based on the monotones sounds of workshops, exposure level of workers could be predicted by equivalent SPL in their stoppages time. Table 2 indicates the results of measurements and the equivalent exposure levels computations in different parts of the workshops. The studied locations are the points with their SPL is higher than the permitted threshold of 85 dB, and also is the main workplace of workers. As according to factory process, the workers should be close to the sets for monitoring, the nosiest places in workshops are in their stoppage or the places where workers are moving. The measurement results have shown that most of the places were not in an appropriate condition considering the noise aspect. Totally, the equivalent sound levels of 21 points (workplace of workers) were higher than 90 dB. There is an agreement at which workers have one hour rest time for every two working hours which means six hours of working day is assigned to working near the devices, 3 hours for rest rooms and one hour for lunch time. As it can be seen from Table 2, the equivalent sound level is higher than 100 dB(A) in some parts of cigarette workshop 2(a) and 2(b). Note that the presented results were related to the most risky points in workshops and it does not represent exposure of all workers. For instance, packaging workers of cigarette workshop 4 have lower exposure level than those who work near devices. In addition to working place, the SPL of rest rooms are efficient in equivalent exposure level. For example, the rest room of packaging workshop with SPL of 77 dB(A) has no suitable condition. Although this sound level is lower than the permissible limit, this with regard to workshop sound, cannot prepare the equivalent sound level (Leq 8 hours) for workers according to ACGIH standard and the Iranian Ministry of Labour (Table 2). Rest room of workshop 1 has better condition (62 dB A) than the other workshops. The total average sound level of various stations of this workshop has lower value. This is because of their new devices and building and also the epoxy-coated floor of the workshop.

The sound characteristics of workshops were defined by the frequency analysis of danger areas at one octave band. The results of frequency analysis performed at those areas with Leq higher than 85 dB (21 areas) are specified in Table 3. As it can be seen from the results, the mean Leq of all studied points of cigarette workshop 1 were higher than 85 dB as a result of the sum of sound levels at 8 frequency ranges. In this workshop, the highest sound levels of examined points were in the range of 63-1000 Hz and lower values were at frequencies below 63 Hz and above 2000 Hz. Assembly of sound levels of cigarette workshop 2(a) were often from frequency 250 to 2000 Hz, the same trend was seen in cigarette workshop 2(b). Similar frequency characteristics of these workshops are because of their same devices. As there are two types of packaging sets in packaging workshop, distribution of sound level is varied at 8th frequency areas where the sound pressure level is generally higher at frequencies above 500 Hz. Different distribution of sound levels in cigarette workshop 4 was observed in which higher sound levels were often assembled at mid and high frequencies (500-4000 Hz).

As it can be seen from Fig. 1, there is no significant difference between noise levels of 21 points frequency analysis of five workshops although the mean noise levels of workshop number 4 has significant difference compared to other workshops at frequency lower than 125 Hz. Totally, the maximum sound levels were ranged at frequencies 200 Hz till 500 Hz. The average change of sound levels have almost followed a pattern in all five workshops where the peak of noise levels were seen in cigarette workshop 2(a) at frequency 1000 Hz.

DISCUSSION

Environmental noise measurements were performed in 565 stations of tobacco workshops. According to the classification of areas with risky noise, it was found that the factory has not a desirable condition considering noise aspect where only four stations belong to safe area. Moreover, through all measurement stations 230 (40%) and 331 (58.5%) of stations were included in caution and danger areas respectively. Older devices, not making use of noise control equipments, lack of proper maintenance and repair in an exact time and using inappropriate material for building that makes sound reflections, were the reasons for maximum danger areas of cigarette workshop 2(b). Respectively, cigarette workshop 2(a) and packaging workshop with 89 and 68.2 percent make the next levels. The main reason for high sound pressure in these workshops is due to their old and worn-out devices. In these three workshops, devices have been used over 35 years. According to rest-work system, it was predicted that the workers' noise exposure is higher than threshold limit values at stations classified into danger areas. These predictions were verified by results of Table 2 in which all 21 measurement points confirmed that the equivalent noise exposure of workers who are working at these parts, was between 90 and 100 dB.

Furthermore, the statistical analysis of *t*-test (Table 4) and Pearson correlation test (Table 5) performed in SPSS 16 have shown that there is a significant linear correlation between environmental sound levels and 8 hours exposure level in these points (sign: 0.000, p-value: 0.01), (sign: 0.000, Pearson correlation: 0.944). Thus, it can be predicted that the same exposure level was existed in other areas included in danger areas during 10 hours. This condition is slightly better in workshop number 4 and especially workshop number 1 owing to its least number of danger points (5.9 percent through workshop stations). Using modern equipments and type of building materials, which is a reason for low sound levels in this workshop, is considered as the strength aspect of management. The rotor parts of these devices located inside the glass container not only provide the operator's vision with more safety but also make less noise pollution. Polymer epoxy type used in floor of workshop 1 was the appropriate one among all mentioned workshops. Similar findings were shown by Booth (1976). This study has emphasized on application of noise damping materials and their proper maintenance. Besides the device's noise, compressed air pumps used to clean the machines and workers' clothes is considered as a source of annoying noise. Frequency analysis of studied stations showed that most devices are ranged approximately at mid and high frequencies in which awareness of this issue is extremely prominent in selection and design of an absorber. For instance, application of membrane absorbers in cigarette workshop 4, where most of sound levels are included at high frequencies, could not be profitable as a result of the effective performance of this absorber at low frequencies. However, cigarette workshop 1 can be a suitable option as its sound characteristics were higher at low frequencies. The study carried out by Ackermann supports our finding that different materials should be applied for places with low and high frequencies (Ackermann et al. 1988).

The sound pressure level was almost high in all workshops at frequency 4000 Hz according to Table 3. This can increase the probability of suffering from permanent threshold shift (PTS) in those people who are exposed to noise pollution for long periods. These findings correspond to those of Ahmed et al. (2001), who compared the hearing damage of two groups of workers; 269 workers with Leq (8 hours) higher than 85 dB as the sample group and 99 workers as the control group. They declared that hearing damage of exposed group is significantly higher than that of control group at frequency 4 KHz. It seems that the work-rest system of this factory is desirable, because there is one hour relaxation per 2 working hours. However, according to ACGIH standard of noise level above 85 dB; work time should be halved with each extra 3 dB, it can be stated that the period of time should be decreased to 2 hours for a worker who is working near devices of packaging workshop, with a 6 hour-day noise exposure at 90 dB(A). Considering the management viewpoint, this issue is impossible as it faces with high costs. On the other hand, carelessness with this situation can impose heavy losses on workforce of the country as well as on the management of the company. Moreover, the mentioned amount of noise exposure could increase the risk of accident

Table 1: Condition of noise measurement stations in five studied workshops.

Cigarette workshop Type	No. of stations	Safe areas ***		Caution area**		Danger areas*		L_{min}	L_{max}
		N	P	N	P	N	P		
4	138	3	2.17	67	48.5	68	49.3	68	91.2
2(a)	136	0	0	15	11	124	89	86.8	94.3
2(b)	62	0	0	2	3.2	60	96.8	84.3	95.5
Packaging	110	0	0	35	31.8	75	68.2	80.5	94.5
1	119	1	0.84	111	93.2	7	5.9	74.0	88.0

* Areas with Leq ≥ 85; ** Areas with Leq 75-85; *** Areas with Leq ≥ 75; N = Number; P = Percent

Table 2: Workers' noise exposure at 21 points with high risk during 10 hours shift work.

Workshops	Site No.	Work place h	Work place Leq(dB A)	Rest Room h	Rest Room Leq(dB A)	Dining Hall h	Dining Hall Leq (dB A)	Leq (dBA)	Leq8hr (dBA)
4	1	6	84.12	3	64	1	69	92.91	91.9
	2	6	87.16	3	64	1	69	95.93	95.0
	3	6	87.84	3	64	1	69	97.6	96.6
	4	6	88.72	3	64	1	69	97.49	96.5
	5	6	85.7	3	64	1	69	94.8	93.5
2(a)	1	6	92.18	3	71	1	69	100.95	100.0
	2	6	89.63	3	71	1	69	98.42	97.4
	3	6	90.2	3	71	1	69	98.98	98.0
	4	6	90.13	3	71	1	69	98.9	97.9
2(b)	1	6	93.2	3	70	1	69	102.10	101.2
	2	6	90.5	3	70	1	69	99.28	98.3
	3	6	89.32	3	70	1	69	98.10	97.1
packaging	1	6	88.21	3	77	1	69	97.0	96.0
	2	6	86.45	3	77	1	69	95.4	94.5
	3	6	89.20	3	77	1	69	97.9	96.9
	4	6	87.3	3	77	1	69	96.2	95.3
	5	6	88.0	3	77	1	69	96.9	96.0
1	1	6	88.1	3	62	1	69	96.8	95.9
	2	6	89.5	3	62	1	69	96.26	97.3
	3	6	87.57	3	62	1	69	96.34	95.4
	4	6	88.51	3	62	1	69	97.26	96.3

occurrence. Based on authors findings most number of accidents in factories was related to these workshops during 2004 and 2008. The results of Girard et al. (2009) were in agreement with the findings of this study. They showed that occurrence rate of work related accidents was increased by exposures to high sound levels. Old devices not only make acoustic and safety problems but also due to their various defects that arises during work, cut the production process and impose lots of losses to efficiency of companies. Nonetheless, new workshops with lower number of workers have higher efficiency and lower noise problems.

CONCLUSION

According to above subjects, it can be stated that the cigarette production industry has left the old production process, though this industry still retains its noisy nature. Rotor and breaker parts of devices are the reason for noise pollution. Also, the ventilation systems and high pressure pumps that are used for cleaning have significant impact on mean sound pressure level. Based on considerable number of noise areas with high risk in this factory, hearing loss can be predicted in long term. This problem especially in older parts of factory, i.e., cigarette 2(a), 2(b) workshops and packaging workshop, in which workers have worked near older devices and have more years of experience, is more probable. Besides hearing loss, lack of proper communication between individuals, distortion of interaction, nervous exhaustion and decrease in efficiency are the effects that can be observed. Therefore, to improve the noise condition in this factory, the following suggestions are recommended: proper maintenance and repair of devices at the exact time, timely replacement of those older parts that make more noise pollution, use of materials with less reflection on the floor and walls, application of mixed shelters for sound absorp-

Table 3: Computations of frequency analysis and sound loudness at one octave band.

Workshop		Site No.	Fr (Hz) 31.5	63	125	250	500	1000	2000	4000	8000	Sound loudness Phone	Total Leq (dB)
4	LP (dB)	1	35.7	48.6	63.9	69.5	76.0	77.6	78.4	80.3	76.0	93.9	85.12
		2	33.8	53.0	65.3	72.6	78.8	81.8	81.9	82.5	77.9	97.58	88.16
		3	36.8	52.2	65.8	82.8	77.9	81.2	81.6	82.5	77.4	97.58	88.84
		4	69.3	68.1	81.8	77.9	82.6	82.7	81.4	81.7	77.5	98.22	89.72
		5	71.3	71.4	76.7	84.2	76.0	74.7	74.7	74.7	70.0	92.9	86.7
2(a)	LP (dB)	1	80.3	82.5	81.9	86.1	87.5	86.3	79.6	80.3	76.4	99.15	93.18
		2	81.8	82.9	77.3	82.8	84.8	88.4	84.1	84.0	82.4	101.5	93.6
		3	75.4	81.0	80.7	82.9	84.4	85.4	83.3	81.9	79.2	99.9	91.90
		4	70.8	77.5	78.1	80.4	86.2	86.7	85.0	82.7	82.1	101.3	92.53
2(b)	LP (dB)	1	75.0	85.7	80.3	83.7	87.1	87.0	86.7	82.0	86.4	102.2	94.5
		2	70.8	77.5	78.1	80.4	86.2	86.2	86.7	85.0	82.7	101.3	92.5
		3	77.2	81.4	78.8	82.4	84.4	86.4	85.6	83.3	82.6	102.2	92.8
packaging	LP (dB)	1	80.8	72.9	74.5	80.3	79.3	81.7	79.6	80.5	81.0	97.77	89.23
		2	72.8	72.9	71.2	76.6	76.9	78.4	78.8	79.8	79.6	96.2	86.8
		3	73.0	75.5	76.9	77.0	80.2	80.9	84.0	87.9	88.0	101.9	92.74
		4	73.6	75.2	75.3	80.3	82.0	82.5	82.7	83.2	81.9	97.52	90.35
		5	72.9	76.1	74.6	77.8	79.8	81.4	81.6	82.3	81.6	98.82	89.25
1	LP (dB)	1	74.9	76.9	80.8	81.2	82.1	80.8	80.1	77.3	74.0	96.76	89.01
		2	76.8	87.7	90.6	87.3	82.5	83.5	81.3	80.0	77.1	100.7	94.7
		3	73.0	81.1	82.6	86.9	82.5	82.0	81	79.9	79.5	98.94	91.67
		4	75	75.4	79.5	77.5	81.2	79.7	77.1	75.1	72.1	94.62	87.3

Table 4: Statistical analysis of *t*-test; relation between environmental sound levels and 8-hr exposure.

	One-Sample Test Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence interval of the difference Lower	Upper
exposure	197.647	20	0.000	88.64476	87.7092	89.5803
Leq8	216.197	20	0.000	96.52381	95.5925	97.4551

Table 5: Statistical analysis of Pearson correlation test; relation between environmental sound levels and 8-hr exposure.

	Correlations	exposure	Leq 8
exposure	Pearson Correlation	1	0.994**
	Sig. (2-tailed)		0.000
	N	21	21
Leq 8	Pearson Correlation	0.994**	1
	Sig. (2-tailed)	0.000	
	N	21	21

tion based on noise frequency, improvement of rest time, alternating those jobs that do not need any especial experience, appropriate use of personal protective equipment and proper training of occupational health issues.

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