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APPLICATION OF ERGONOMIC ASPECTS TO THE WELDING PRACTICE IN SPECIAL CHILDREN'S GUIDANCE INSTITUTION CLASS II TOMOHON NORTH SULAWESI INDONESIA

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ABSTRACT

Objective: To assess the number of aspects of ergonomics application in the welding practice in Special Children's Guidance Institution that has the duty and function to foster, guide and protect every correctional student who has problems with the law.

Method: The design in this study is an analytical-observational approach. This research was conducted by observing the aspect of ergonomics. This research is focused on the training process of welding practices. Respondents from this study amounted to 14 respondents who took welding training. The study was conducted in May 2021. Assessment of working posture using REBA Measurements is made of physical environments.

Result: Based on observations and measurements found REBA score results on welding and material cutting activities with scores 11 and 8 with very high risk and high risks categories so that there needs to be immediate improvement possible. Welding Program is seen from the application of ergonomic aspects, namely nutritional status, work attitude, use of muscle power, environmental conditions, time conditions, working conditions. Social conditions, information and conditions of human-machine interaction have been implemented, although some aspects still need to be implemented to create safe, comfortable, healthy, efficient and effective working conditions.

Conclusion: The proposed improvement of work posture while working on welding is to redesign the work station and design work aids based on ergonomic aspects such as the procurement of work desks that are following worker anthropometry to reduce the risk of non-ergonomic work posture.

Keywords: *Aspects of Ergonomic, Occupational Health, Welding*

1. Introduction

Ergonomics is an important and very broad component of activities, including the adjustment of tools, working methods, and work environment on human abilities, abilities and limitations to create healthy, safe, comfortable, efficient and effective working conditions to achieve work productivity and human welfare. From this definition, it can

be seen that all disciplines that talk about humans in their activities, whether they are at rest, doing recreation, sports, or during activities at work will involve ergonomics in it (Sutjana, 2015).

In work activities, either manually or in general, attention to comfort, health and safety of human work will unknowingly affect the effectiveness, efficiency and productivity of work. Ergonomics which is generally defined as 'the study of work' has been able to bring about significant changes in implementing the concept of increasing productivity through efficient use of labor and division of labor based on specialist human labor skills (Bridger, 1995; Sander and McCormick, 1992).

Most people will be involved in the work process both physically and mentally. Work is an uncontrollable part of their life. In other words, work refers to all activities of human life that involve goals or efforts. Work activities usually involve the use of machines and tools to support hu-mans in completing their work.

With the increasing complexity of machines and work equipment used, the ergonomics approach in job planning is not fully adequate. Therefore, to ensure the achievement of maximum efficiency from each operation, minimize the possibility of errors made by humans, reduce fatigue and attempt to eliminate any risk to the operator, it is necessary to plan working conditions based on anatomical, physiological and psychological considerations of the capacities and limitations. humans (Susihono, 2017).

LPKA (Lembaga Pembinaan Khusus Anak) Kelas II Tomohon is a Children's Special Guidance Institution that has the duty and function to foster, guide and protect every correctional student who has problems with the law. The way of education is also different from adult inmates where the correctional students are more focused on coaching related to learning and fostering creativity possessed by correctional students.

One of the coaching programs implemented is welding process training to improve the creativity of correctional students, there are 14 coaching children as participants in the welding process training with a working time of 5 hours of training for 5 days a week.

Every job is always at risk of danger. Likewise in the welding process. Hazards encountered in welding include electric welding machine shock, welding electrode radiation, smoke. According to Yusmita, et al (2018) in general the dangers of welding that often occur are electric shock, skin irritation, eye irritation, injuries and skeletal muscle injuries, respiratory problems, burns, increased body temperature that triggers heat stress, back and shoulder pain, boredom, boredom and noise. In addition, the danger posed is working with tools that are not commonly used and working with unnatural work attitudes, which causes physiological disturbances to workers.

The main purpose of implementation ergonomics is to increase productivity and work protection. In other words, ergonomics concerns work planning and safe working conditions for the health of workers both physically and mentally. An understanding of the important role of ergonomics in every activity must be realized by every worker with a serious effort to participate in implementing it following environmental conditions.

To see some Implementation aspects of ergonomics, it is necessary to make several visits to LPKA Kelas II Tomohon. During the visit, observations and measurements were made on working conditions, equipment and work facilities in the welding process.

2. Materials and Method

The design in this study is an analytical-observational approach, namely observation without intervention to reveal the facts of a cause and effect described descriptively. This research was conducted by observing the workings and work environment including interactions between humans, human-machine interactions, and the physical environment. This research is focused on the welding practice training process. This research was conducted on May 2021.

The physical environment measured was lighting (lux), noise (dB), temperature (0C) and humidity (%). The results of the measurement of physical environmental conditions are then compared with the physical environmental conditions

in the Limits Threshold Value (LTV) regulation based on the Decree of the Minister of Health of the Republic of Indonesia No. 1405/MEN-KES/SK/XI/2002. Observations were taken at 5 measurement points in the work area and then the average was calculated to determine the magnitude of physical environmental factors on workers' body exposure.

Observations on nutritional status, use of muscle power, time conditions, and social conditions were carried out by interviewing workers, while observations on body posture, information conditions, and human-machine interactions were carried out by recording activities in the form of pictures and videos to make them easier to observe and analyze.

3. Results

The first stage is cutting iron plates and iron rods according to size to be shaped into items according to what was set by the training instructor. Cutting is done using work equipment, namely a cutting grinder. The next stage after the iron and plate are cut to size, then the process is continued by doing spot welding (welding point). The spots welding process aims to lock the plate movement so that it does not shift when the welding process is carried out. This stage is carried out below that is right on the floor.

The next step is when spot welding has been done, then do the whole welding. So that the two materials to be joined through the welding process become connected into one whole. The last stage in the welding process is when it has become an object in the form of goods, then the final stage is sharpening/grinding the results of the welding process at each weld joint. This process is carried out using a grinder in a squatting or standing position.

3.1 Characteristics of Respondents

Based on table 1 it can be seen that the characteristics of respondents are known to be the age of the respondents, a total of 14 respondents have an average of 19.3 years with a range of 18-21 years, an average height of 168.7 cm with a range of 159-176 cm, a weight of 60.3 kg with a range of 45-73 kg, and Body Mass Index has an average of 21.2 with a range of 15.66-24.14 kg/m^2.

Table 1. Characteristic of Respondents (N=14)

Variable	Mean	SB	Range
Age (Year)	19.3	0.88	18-21
Height (cm)	168.7	5.30	159-176
Weight (kg)	60.3	7.42	45-73
BMI (kg/m2)	21.2	2.25	15.66-24.14

3.2 Aspects of Ergonomics

3.2.1. Nutritional Status

Based on the data obtained from table 1 of the characteristics of the respondents, the nutritional status of workers in the welding process can be described using a body mass index (BMI) in the normal status of 21.2 in the range of 15.25-24.14.

3.2.2. Work Posture

Observations of the work attitude carried out by workers in welding process activities can be seen in Figure 1 below. Based on Figure 1, it can be seen that the workers' body postures when doing welding with unnatural work postures, namely forced work postures in a bent position. And on table 2 can be seen action level Score REBA, In the assessment of working posture with the Rapid Entire Body Assessment (REBA) method obtained the REBA score is 11 with action level 4 (four). The results of the REBA score with action level 4 state that welding activity is at a very high risks level and remedial action is needed at this time. Welding activities are carried out on the floor and without using a special work table, so workers have the risk of pain in the legs and waist. Doing work with a forced work attitude will risk musculoskeletal disorders. This kind of work posture is done for quite a long time, which is for 10 minutes which is done repeatedly.

Figure 1. Work Posture of the Welding Process

Table 2. Score REBA

Score	Risk Level	Remedial Action	Level
1	Negligible Risk	No Need	0
2-3	Low Risk	Change May be Needed	1
4-7	Medium Risk	Change Soon	2
8-10	High Risk	Implement Change	3
11-15	Very High Risk	Implement Change	4

Based on Figure 3, it can be seen that the body posture of workers when doing material cutting activities is carried out with an unnatural working posture in a squatting position. This results in the risk of musculoskeletal disorders, and flexed legs lead to the risk of soreness in the legs and waist. These activities are carried out for a relatively long time and repeatedly.

Based on figure 4 below, showing the results of REBA score assessment in workers of the material cutting section, the score result is 8 with action level 3 (three). The results of the REBA score with action level 3 state that the activity in the process of cutting material using grinding is at a high risks level and needs immediate remedial action.

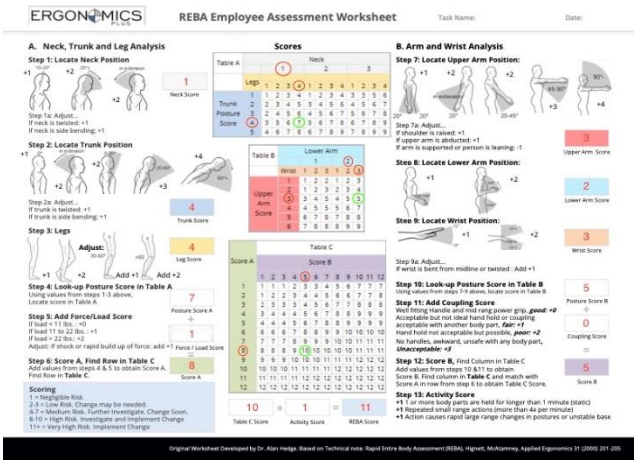

Figure 2. Score REBA Assessment Worksheet on Welding Activity

Figure 3. Work Posture of the Cutting Materials Process

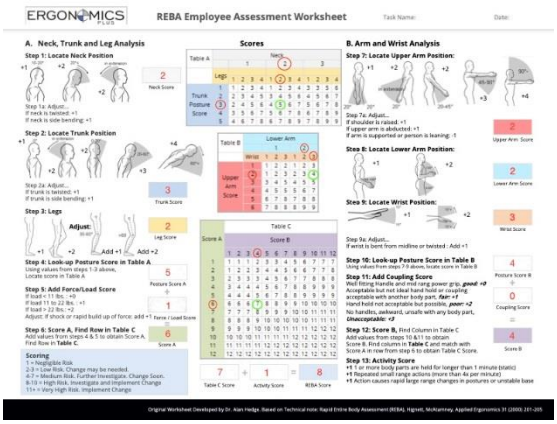

Figure 4. Score REBA Assessment Worksheet on Material Cutting

3.2.3. Biomechanical

Use of muscle power when carrying out several work activities is included in activities that do not require the use of excessive muscle power.

3.2.4. Work Environment Conditions

Based on the results of measurements of physical environmental conditions in the work area as follows:

Table 3. Measurement of working environment conditions

Indicators	Take at Point					Mean
	1	2	3	4	5	
Iluminate (lux)	170	168	88	153	150	145.8
Temperature (^{0}C)	29	29	29	29	29	29
Humidity (%)	65	65	65	65	65	65
Noise (dBA)	95.7	92.3	92.6	70.8	90.2	88.32

Based on table 3 above, it is known that the work area has an average lighting level of 145.8 lux, an ambient temperature of 29 0C, air humidity of 65%, and noise of 88,32 dB(A).

3.2.5. Time Conditions

To recover energy, of course, active rest time is needed to release fatigue in a moment and reduce the workload (Susihono, 2014). The working hours as described above are appropriate even under the provisions set by the government, namely 5 working hours. Meanwhile, active rest time is not given.

3.2.6. Social Conditions

Conditions Socio-cultural conditions of work can be in the form of interactions between coworkers, family communities, and companies (Chapain, 1997). Conditions in the welding training program at LPKA Kelas II Tomohon include the existence of a briefing between workers in the morning before practical activities begin. This is an effort to remind workers of the possibility of work accidents, in addition to directing what work will be done on that day. lack of communication between instructors and workers can result in errors in completing work.

Meanwhile, other cultures such as the lack of awareness of workers to use Personal Protective Equipment (PPE) when doing welding so that the risk of work accidents or work related diseases. Personal protective equipment in the welding process in general that must be used includes; Welding masks, safety shoes, heat-resistant gloves, safety glasses, masks, aprons, earplugs.

3.2.7. Conditions of Information

Condition of information in the workshop area is that there is no installation of information to avoid work accidents, information on where to take goods and place items back, as well as an effort to minimize asking questions to the workshop instructor. Then there is no information board regarding the work targets being worked on as information to be achieved.

There is no information on the division of work and duties of workers for a certain period so that the job descriptions of workers have not been documented in writing. The workshop work area has no instructions regarding safe and unsafe evacuation routes in a work area. For example, the evacuation route in the event of a work accident.

3.2.8. Human-Machine Interaction

Human-machine interaction can be found in the process of using work equipment when cutting materials using wooden mats so that the work equipment does not hit the floor. In the welding process, workers carry out activities on the floor due to the unavailability of a special work table, resulting in workers doing welding activities with unnatural work attitudes for a relatively long time.

4. Discussion

Age is one of the factors of physical condition that can affect human performance in carrying out work activities. According to Bridger (2003) the occurrence of bone degradation occurs starting at the age of 30 years along with an increase in a person's age. This bone degradation causes a decrease in stability in muscles and bones so that

the older the age, the higher the risk of experiencing a decrease in bone elasticity resulting in musculoskeletal disorders (Kurniasih, 2009 in Prawira, 2017).

The age of the welding workshop workers who are the respondents are between the ages of 18 to 21 years. The age of workers is also included in the category of productive age where the age of workers is between the ages of 15 to 60 years (ILO, 2005). According to the theory from Oborne, (1995) that musculoskeletal complaints are usually experienced by someone at working age, namely 24-65 years and the first complaint is usually experienced at the age of 35 years and complaints will increase with age.

In addition, height and weight are factors that can cause skeletal muscle complaints. Kurniasih (2009) states that someone with a short body size is associated with complaints on the neck and shoulders. In the welding process, workers can be at risk of skeletal muscle complaints because workers do not use a special work table that is by the worker's anthropometry, causing a mismatch between the work station and the worker which triggers an unnatural work attitude. The average height of workers is 168,7 cm and the weight is 60,3 kg. Data on height and weight were compared to determine the average Body Mass Index of welding workers, which was 21.2 kg/m2. Body mass index (BMI) is an approach that is quite practical and simple to assess a person's nutritional status (Tandirerung, 2019). Body mass index is classified, among others: underweight, normal, overweight and obese. The average body mass index of welding workshop workers can be said to be in the normal category. Nutritional status is the state of the body as a result of food consumption and the use of nutrients. The abnormal nutritional status will indicate an unfavorable body condition. This body condition will affect workers in their activities and can cause work fatigue (Hanifah, 2021).

The results showed that the nutritional status of the workers as seen from the average body mass index of 14 workers was in the normal category, namely 21.2 kg/m2, which indicated that the nutritional status of the workers was in good condition. A person with a body mass index that is not good or not normal is easy to experience fatigue compared to those who are classified as normal. Bodyweight that is less tired due to lack of intake or energy in the body that supports body movement and excessive body weight will seek more rest time than someone who has a normal body mass index (Hanifah, 2021).

Work posture is influenced by the unfavorable condition of the work station. All workers work on non-ergonomic workstations. In Figure 1 it can be seen that the welding process is carried out on the floor without using a special table. Figure 3 shows the sharpening process which was also carried out with non-ergonomic work stations. The results of observations on observations of welding workshop workers, almost all workers do their work with forced or unnatural posture. As well as very high risk will occur when viewed from the REBA assessment obtained, namely score 8 with a high risks category on material cutting activity, then a score of 11 from the REBA assessment with a very high risk occurs in welding activity. The onset of risk is caused because welding workers do not understand the risks of working with a state of bending and squatting. Welding workers also work with a long enough duration of time so that later it will result in the onset of musculoskeletal disorders and work fatigue.

Low back pain is often referred to as a musculoskeletal complaint, which is a skeletal muscle disorder that is most at risk for complaints of aches, pains, stiffness and aches. If the work attitude is carried out continuously for a long period, the risk of musculoskeletal disorders will get worse. If the workstation is not ergonomic, it can cause the work position to be at risk for musculoskeletal disorders (Perma-tasari, 2018). Research conducted by Larono et al. (2017) in Permatasari (2018) found the results of research that work attitudes have a significant relationship with musculoskeletal disorders.

Biomechanics or often referred to as the use of muscle power is a combination of scientific mechanics, anthropometry and basic medical science (biology and physiology) (Mas'idah et al, 2009). In work activities, the strength of muscle work depends on the position of the working limb, the direction of movement and the difference in strength between the body parts. In addition, the speed and accuracy as well as the resistance of body tissues to material loads that can affect the biomechanics of the worker's posture. From the results of observations through field observations, it was seen that there was no excessive muscle

exertion in the welding process. In the welding process, no material load needs to be lifted by mobilizing most of the workers' muscle power.

According to Mas'idah et al (2009) classifying the limits of loading and transporting materials based on age, among others: men under the age of 16 years the maximum lift is 14 kg, men aged 16-18 years the maximum lift is 18 kg, men aged over 18 years do not there is a lifting limit, for women aged 16-18 years the maximum lift is 11 kg, while for women over 18 the maximum allowed lift is 16 kg. These lifting limits can help reduce the risk of low back pain including reducing pain, aches and fractures. These limitations can reduce discomfort in work related to manual material handling. Humans besides using tools as a way to complete a job, other factors affect the productivity of human work in their work, namely environmental factors (Putra, 2017).

Measurement of work environmental conditions in the welding workshop workspace obtained an average lighting intensity of 145,8 lux. The lighting in this workspace used is natural lighting and artificial lighting. However, artificial lighting in the form of a fluorescent lamp (NEON) is lit only at one point in the center of the room which is 8 watts. The level of lighting in the workspace from natural lighting is sunlight that enters through the ventilation on the right and left sides of the room which is sufficient for lighting to do work. Following the Health Requirements for Office and Industrial Work Environments, welding is included in the category of rough and non-continuous work with a description of work with machinery and rough assembly having a minimum lighting level of 300 lux. When viewed from the measurement results obtained are far from the requirements set by the government.

Optimal lighting needs are needed. Good lighting levels are one of the factors to provide good viewing conditions. A good level of lighting will make it easier for workers to see and reduce errors in doing work. The ability of the eye to see objects is influenced by the size of the object, the degree of contrast between the object and its surroundings, brightness, length of attachment, and color and texture that have a psychological effect on humans.

Workspace temperature measurement data obtained in table 3 shows a temperature value of 29 0C with a relative humidity of 65%. From the results of the temperature and humidity data obtained, it can be said that the room is in a comfortable condition. Humidity is closely related to air temperature, the lower the temperature, the higher the humidity value and vice versa. The influence caused by humidity and temperature that is not ergonomic can cause a large reduction in body heat, besides that it can also cause a faster heart rate due to the more active blood circulation to meet oxygen consumption. This can lead to the emergence of the risk of fatigue at work. By the Decree of the Minister of Health Number: 1405/Menkes/SK/XI/2002, concerning the Threshold Value of the Work Environment for a room temperature of 18-300 with a relative humidity of 65-90%.

Noise can be defined as an unwanted sound. noise with an intensity that exceeds normal limits originating from business activities in a certain level and time can cause communication disorders, health problems, and have an impact on comfort (Mukhlish et al, 2018). The results of the measurements are shown in table 2 above, the average is 88, 32 dB(A). The noise comes from the grinding machine used in the process of cutting the welding material. 2 grinding machines are active simultaneously, and other sources of noise are generated by forging materials in the form of iron using a hammer. Noise generated in the workplace greatly affects the increase in blood pressure and human pulse. Sympathetic nerves that get stimulated will affect the radial arteries and veins causing vasoconstriction. If this happens for a period of up to five years, it can cause hypertension and have a 60% higher risk of death from cardiovascular disease for more than 10 years, compared to workers who have never been exposed to noise (Zeeb, 2017).

In the Regulation of the Minister of Manpower and Transmigration No. PER/13/MEN/X/2011 regarding the noise threshold value of 85 dB(A). This value when compared with the results of field observations of 88.32 dB(A) is still acceptable to workers without causing illness or health problems at work for less than 8 hours a day or 50 hours a week.

The length of time in work in a day that has been set is generally 6-8 hours of work. The efficient amount of time for a week is between 40-48 hours divided into 5 or 6 working days and the

maximum additional working time that is still efficient is 30 minutes. In addition, it is necessary to arrange special rest periods so that the ability to work, physical fitness can be recovered or maintained. From the results of observations made on the length of work in welding is still inefficient time, namely 5 hours of work a day.

Tarwaka, et al (2004) stated that the heavier the workload or the longer a person's working time, work fatigue will arise. The excessive workload can cause muscle fatigue which is characterized by tremors or muscle pain. Fatigue can be reduced in many ways, by managing time at work and the workplace environment. Many things can be applied in implementing work and rest periods following applicable regulations.

Personal Protective Equipment (PPE) is a tool that can protect a person whose function is to eliminate the possibility of all members of the human body from potential hazards. From the observations and interviews of several welding workers, there are still many who are not accustomed to using PPE because workers claim to be more comfortable holding or moving their bodies when doing work.

Before starting the welding activities, in the morning the instructor conducts a briefing to all workers. To explain the job description and remind the importance of occupational health and safety that need to be considered in welding. Briefings and warnings are given when welding workers do not use personal protective equipment. Submission of details of tasks, procedures and work rules to workers in a clear and detailed manner can reduce the incidence of work errors. From the results of observations related to the condition of the information applied, among others: briefing, equalization of details of tasks, procedures, rules, and targets for work achievements that have been carried out. Meanwhile, written information is still lacking.

In the delivery of information, several systems can be used, including verbal communication, written information either directly or indirectly, posted on bulletin boards or in the form of work slogans that are posted in the workplace at any time, and in the form of a work reference book (Manuaba, 2003). The use of appropriate information media by using proportional sizes, colors and placements can facilitate the production process and increase work productivity.

Human-machine interaction compatibility. In this case, the use of work tools adapted to the elements of anatomy, psychology, environment and occupational health. According to Pheasant (1988), there are three important pieces of information needed to be able to choose the best size that creates compatibility between workers and machines, namely the body size characteristics of the user population. From the results of observations made regarding aspects of human-machine interaction, there are still many that are not ergonomic, such as the unavailability of a special work table when doing welding, thus requiring workers to do welding in a squatting position.

Incompatibility of work conditions in the aspect of dis-harmony of human-machine interaction can also cause workers' lack of understanding of healthy and safe work attitudes. This less harmonious human-machine interaction condition causes forced labor attitudes, repeated musculoskeletal disorders causing premature fatigue (Grandjean, 1993; Pulat, 1992; Sanders & McCormic, 1987). Therefore, it is necessary to take corrective steps, including designing a special worktable according to the size of the worker's body which can minimize unnatural work posture.

The effect of human-machine interaction on musculoskeletal system disorders according to Grandjean (1993), broadly speaking, muscle complaints are grouped into two, namely temporary complaints, muscle complaints that occur when the muscles receive static loads, these complaints will immediately disappear when the loading is stopped, and persistent complaints, permanent muscle complaints. Even if the loading is discontinued. He's influenced of man-machine interaction to fatigue. Fatigue for each person is subjective because it is associated with feelings. The results of research by the expert state that the state and feeling of fatigue are functional reactions from the center of consciousness, namely the cerebral cortex, which is influenced by two antagonistic systems, namely the inhibitory system (inhibition) and the motion system (activation) (Sudiajeng, et al, 2011).

5. Conclusion

In general, it can be concluded that most of the ergonomic aspects have been implemented according to the description above in the welding training program conducted by LPKA Kelas II Tomohon, although some aspects of ergonomics need to be adjusted and adjusted. Based on calculate of REBA score value on 2 welding workers in LPKA Class II Tomohon is in welding activity obtained REBA score value is 11 with action level 4 which states that welding work is very high risk and REBA score value on material cutting activity obtained REBA score value 8 with high risks action level, so urgent remedial action is needed as soon as possible.

The proposed improvement of work posture while working on welding is to redesign the work station and design work aids based on ergonomic aspects such as the procurement of work desks that are in accordance with worker anthropometry to reduce the risk of non-ergonomic work posture. And based on observations, the level of lighting is inadequate for the type of welding work that only utilizes natural lighting from sunlight to minimize the level of work errors. In the aspect of work posture that needs to be considered again, there is even a need for procurement or planning of work stations that are by anthropometry so that they do not require working with forced labor attitudes. It is necessary to pay attention to aspects of information conditions, such as the existence of bulletin boards, occupational health slogans, and the direction of the evacuation route in the event of a work accident. Then aspects for hu-man-machine interaction need to consider how to use the correct tools work and compliance with work tools to escape from disorders musculoskeletal disorders and the need for a special work table to work in accordance with ergonomic working position. Aspects of social conditions in terms of the use of PPE, it is necessary to foster an understanding of the importance of using PPE to avoid work accidents and occupational diseases.

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Conflicts of Interest

The author declares no conflict of interest.

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