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Analysis of Noise Levels in Manufacturing Processes of the Metallic Industry in Mexicali, Mexico, and Its Effect on the Occupational Health (Auditive System) of Operational Personnel of Manufacturing Areas

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Abstract - The noise levels generated in industrial operations of the metalworking industry are a relevant factor in the occupational health of workers in the manufacturing areas of this type of important industry in the city of Mexicali, Baja California, Mexico and worldwide. This type of environmental ergonomics factor can cause risk to the hearing system of operating personnel, which can cause some types of health symptoms in the ear, one of the main ones being Ménière's disease, which can cause stress in people. Noise levels in the metallic industry usually exceed decibel levels (the maximum being 85 decibels (dB)), so a large part of the workers who operate equipment and machinery in this type of industry and are attended to at least one occasion by medical personnel from the industry where it allowed the development of the research, which greatly supported the improvement of the occupational health of operational personnel in manufacturing areas in this evaluated industry. An automatized system was designed and used to control the noise generated in the metallic industry where was made this investigation, which was made from 2022 to 2023.

Keywords: Occupational health, noise levels, metallic industry, industrial operations, auditive system, automatized system.

1.INTRODUCTION

The metallic industry is one of the industries worldwide that manufactures a wide variety of metal products that are widely used in many activities of daily life. Only, in this type of industry, it generates high intensity

sound vibrations, where there are young workers who, over time, may suffer from some health symptoms in their hearing sense, and the slightly older people who work in this type of industry (Dhawale et al, 2017), these types of health situations complicate their hearing. In this research, an analysis of noise levels is carried out in a metalworking industry located in the city of Mexicali, where around 80 industrial companies of this type of industry are contemplated (AIMM, 2023). This means that a considerable percentage of cases with hearing problems occur in both public and private health institutions (Fredianelli et al, 2022).

1.1 Metallic Industry

Figure 1 shows the principal products manufactured products of the metallic devices and systems in the Mexicali city (Gustavo Lopez Badilla et al, 2016; Baffoe et al, 2022).

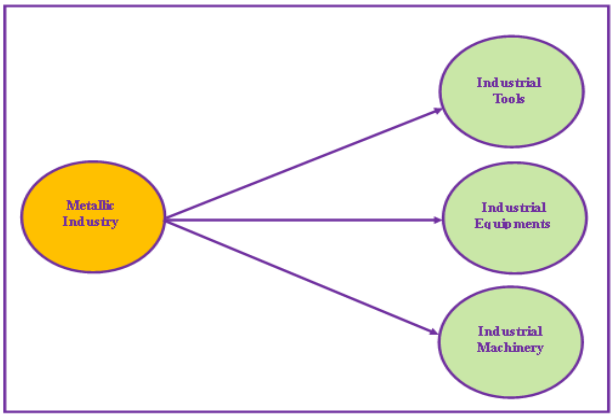


Fig -1:Main metallic products manufactured in the metallic industry of Mexicali (2023)
Source: Analysis of investigation

This industry generates a lot of jobs in all places of the world, where are fabricated a diverse metallic parts, pieces and systems to industrial tools, equipment and machinery, which are utilized in great quantity of different industrial companies to make operations with high effort, as mechanical, electromechanical, pneumatic and hydraulic tools, equipment and machinery. This type of industry has some industrial operations that supports to the manufacturing process with diverse industrial equipment and machinery that are illustrated in table 1 (Murphy et al, 2022).

Table -1: Principal industrial equipment and machinery utilized in the metallic industry of Mexicali (2023)

Industrial Equipments and Machinery	Function
CNC machines	Are utilized to fabricate small parts with specialized actions, as example box used to boiler pilots with special structures
Foundry	Have the function of manufactures parts to automotive and industrial batteries.
Lathes	Are used for make some industrial operations as machining, threading, cutting, boring, cylindering, roughing and slotting to obtain geometrically shaped pieces and generated by a revolution action.

Matrix Equipment	Have the function to fabricates molds to be used in some industrial activities to manufactures metallic or plastics parts of industrial devices and systems, used in the real life.
Milling Cutters	Elaborates machining work by chip removal using specialized tools
Rectification Equipment	Is used in a final step of the manufacturing process in a metallic industry to improve characteristics as dimensional tolerance and surface finish of any industrial product.
Welds	Utilizes inert gases to make its function and soldering metallic parts to metallic structures to be utilized essentially in construction activities.

Table 1 shows the main industrial operations of the metallic industry of the Mexicali city, which are utilized by specialized workers, that supports in the fabrication of the metallic products of this type of industry of the northwest of the Mexican Republic that is an important industry, and some metallic products are commercialized in this region and some places at the world.

1.2 Industrial Operations

In industrial processes, productivity and quality levels are constantly being evaluated with various statistical tools, which show the correlation indices of the factors that can generate important aspects in the operational performance of the personnel who work in the manufacturing areas and the industrial equipment, devices, systems and machinery (Lokhande et al, 2018), which carries out production operations. In the metalworking industry, relevant situations are sometimes contemplated, because the industrial equipment and machinery used are of a specialized type, which can generate noise levels higher than those allowed in closed places, such as this type of industry. These types of actions can cause damage to the hearing system of workers in the manufacturing area, and little by little they can lose hearing and even lose it forever (Bansal, 2012). Due to this, this scientific study was generated, with the objective of supporting workers in the manufacturing area through specialized occupational medicine strategies, where the working conditions of the noise levels of various industrial equipment and machinery were evaluated, which It was related to the operational performance of workers in industrial processes, to cases of medical care in the evaluated industry and to public health institutions in this industrialized city. Table 2 shows the main industrial processes of the metalworking industry where the scientific study was made (Alves et al, 2015).

Table -2: Essential industrial processes in the metallic industry at worldwide (2023)

Industrial Operations	Activity
Drilling	This type of operation is developed with the machining action, where activities are carried out with the tool called a drill or drilling machine, making cuts in metal parts of the products manufactured by the evaluated metalworking industry, managing to carry out the industrial operation in a rotating manner. The tool contains a drill bit, which eliminates chips, there are different types of drills worldwide: hydraulic, electromechanical, magnetic, pneumatic and manual, essentially.
Foundry	Based on this relevant type of industrial process, metal or plastic parts can be made by melting the materials with which they work to develop the final product, which is obtained from a mold,

	where the raw material is placed. the casting process and letting it cool so that it solidifies and is used for the parts of the final manufactured product.
Laminate	It is produced through the steelmaking activity, which once the steel is obtained from the furnace at high temperatures, ingots are formed to be processed into sheets that will be used for construction activities or other types of action with metallic materials, with the objective of manufacturing metal parts for any type of activity.
Milling	This industrial operation is widely used in the metalworking industry, through the milling machine that contains a tool that is constantly rotating, with various types of sharp cutting, developing highly precise actions, essentially, if coupled with a CNC machine. In this way, with this type of machine, production time periods and the number of operating personnel for this type of industrial processes can be reduced.
Turning	It is used to made machining activities in metal materials, mainly sheet type of certain levels of expectation, such as screwing, cutting, making holes, cylindering and making slots of raw materials or pieces considered metal products of the metalworking industry. These types of actions are carried out with specialized equipment and machines such as the CNC (Numeric Control Computer), through specialized computer programs.
Welding	Develops actions for joining metal parts to carry out the assembly process with the union of metal parts, carrying out the action with the casting operation or the function of melting a metal material and joining it with another metal material. Once the welding action is carried out, it is allowed to cool and the joining process between the desired metals is developed to produce the finished metal product.
Wrought	It represents the action of elaborating the deformation of plastics and metals, in actions of heat (hot process) or low temperatures (cold process), in order to obtain pieces with specific figures for certain types of functions of daily life and thereby evaluate certain type of physical properties, the most essential being compression.

With last table, can k now the diverse types of industries operations in the metallic industry at the worldwide, and principally in the metallic industry where was made the investigation, to can determine the type of industrial industry to be utilized and improve the operative yielding of industrial equipment, machinery and systems, and the operative yielding of workers of manufacturing areas (Singh et al, 2018). This was relevant to supports in the increase of the productivity and quality indices in this metallic industry, where was made the scientific study.

1.3 Noise Levels in the Metallic Industry

According to the World Health Organization (WHO) (Licitra, 2012), attention is paid to exposure to high levels of noise that are uncontrollable in industrial companies that are located in a wide variety of cities in various countries, especially in the metalworking industry, have increased, due to the lack of noise control of industrial equipment and machinery (Fredianelli et al, 2021), especially in this type of industries of importance in the manufacturing, especially of metal and plastic products. As mention specialists of this relevant thematic, the four principal industrial operations of the metallic industry were observed in figure 2, which are mentioned above (Schiavoni et al, 2022; Mazinder et al, 2022).

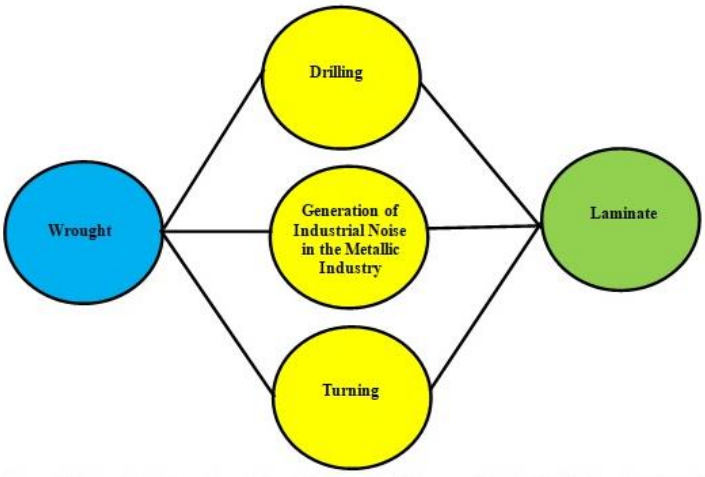


Fig -2:Main industrial operations in the metallic industry that generated high noise levels.in the industrial company of the Tijuana city evaluated (2023)
Source:Analysis of investigation

This type of action has generated concern about the increase in the risk premium factor, where a certain type of concern has been generated on the part of the management, management and supervisory staff due to the large number of visits that occur in the medical departments of industries of this type and in public health institutions, especially, referred especially to the Mexican Republic and the city of Mexicali, Baja California, where this investigation was made. International standards indicate that noise levels greater than 85 dB (decibels) can cause some types of health symptoms in the auditory system, where occasional deafness or hearing loss may occur (Garg et al, 2021); when safety earplugs are not used. Experts in the study of audiology mention that the rates of visits to the doctor for critical hearing symptoms have increased worldwide, with a higher incidence in men than in women, because in the metalworking industry, more people are considered. in the manufacturing areas of the male sex than the female (Akan et al, 2012).

2. METHODOLOGY

In this investigation was made an analysis of the presence of cases of auditive situation critic where was evaluated the next relevant aspects:

a. Correlation analysis of noise levels and the cases of visits to medical service in the metallic industry evaluated and to the Mexican clinical institutions.

b. Cases of auditive situation critical events and the operative yielding of the workers of the manufacturing areas of the metallic industry evaluated.

c. An improvement with automatized system to alert workers about the high noise levels in the manufacturing areas of the metallic industry evaluated.

3. RESULTS

The evaluation of the operative yielding of workers exposed to the noise levels of the industrial equipments and machinery of the metallic industry was relevant and was related with the productivity and quality indices, which is expressed in the next sections.

3.1 Correlation Analysis of Noise Levels and the Cases of Visits to Medical Service

This part of the scientific study was relevant, because was observed the relation of the exposition of noise levels higher than 85 dB, and the main health symptoms, where was reflected some critical clinical symptoms and the possibility to suffer of any health symptoms for the rest of his life. This is illustrated in table 3, where was reflected the most common health symptoms in works of manufacturing areas of the metallic industry located in the Mexicali city, where was made this investigation, observing great concerning of the directive, managers and supervisor people, about the great quantity of clinical visits of his works of the industrial processes.

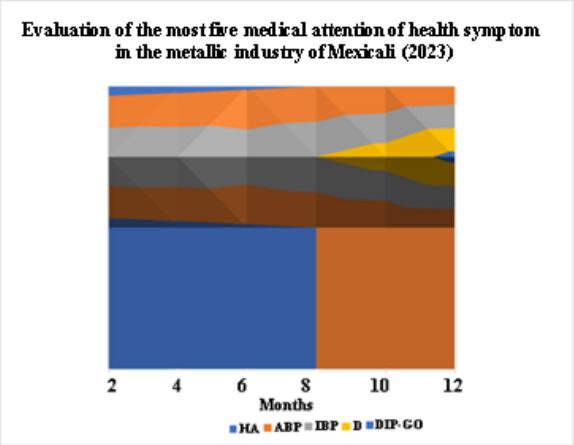
Table -3: Factors of occupational medicine with health damage in workers by the high exposition of noise of the metallic industry evaluated (2023)

Workers	Sex	Industrial Operation Exposed	Period of Exposition, Months	Main Effects of Occupational Health
1	Men	Wrought	6	Headache, acceleration of breathing and pulse, increase in blood pressure and deafness
2	Men	Drilling	4	Headache, decrease in digestive peristalsis, which causes gastritis or colitis and deafness
3	Men	Drilling	5	Headache, neuromuscular problems that cause pain and lack of coordination
4	Women	Laminate	7	Anxiety, decreased night vision, increased fatigue and difficulty sleeping
5	Women	Laminae	6	Anxiety, acceleration of breathing and pulse and headache
6	Men	Turning	9	Increased fatigue and difficulty sleeping, deafness, and anxiety
7	Women	Wrought	10	Neuromuscular problems that cause pain and lack of coordination, increase in blood pressure and deafness
8	Women	Turning	12	Headache, decrease in digestive peristalsis, which causes gastritis or colitis, neuromuscular problems that cause pain and lack of coordination and deafness
9	Women	Drilling	11	Headache, decrease in digestive peristalsis, which causes gastritis or colitis and deafness, anxiety
10	Men	Laminate	9	Headache, decrease in digestive peristalsis, which causes gastritis or colitis, deafness, increased fatigue and difficulty sleeping

Total				

3.2 Cases of Auditive Situation Critic Events and the Operative Yielding

Once the analysis in the previous section was prepared, the five health symptoms with the highest incidence of workers in manufacturing areas due to exposure to high levels of noise, which exceeded most of the working hours, were selected. This was a great concern for the management, managerial and supervisory staff because the workers were afraid of the company having critical hearing health problems and the health symptoms mentioned in the previous section, which is showed in figure 3. In this figure is illustrated the health symptoms by colors, beginning with the light blue color as the most section of the figure, which represents the headache symptom, followed by the orange color that illustrates the acceleration of breathing pulse symptom. Then is showed the increase in blood pressure with the dark blue color, followed by the light gray color represented by the deafness and finally is illustrated with the yellow color presenting the decrease indigestive peristalsis, which causes gastritis or colitis. This is shown in figure 3. The presence of the five health symptoms were concerned to the directive, managers and supervisors' people, because some workers with a lot experience in the industrial operations were absent, and some industrial activities were made with some manufactured products with some defects as defective products fabricated, decreasing the productivity and quality levels in the metallic industry evaluated. The noise levels were higher than 85 dB in around six hours of each day in each shift, being concerned it.



Headache (HA), Acceleration of breathing and pulse (ABP), Increase in Blood Pressure (IBP), Deafness (D) Decrease In digestive Peristalsis (DIP-GO), which causes gastritis or colitis.

Fig -3:Evaluation of the auditive cases by high noise levels in the metallic industry analyzed (2023).

3.3 Evaluation of the Noise Levels in the Metallic Industry

The evaluation of noise levels was relevant to obtain important information and determine the principal causes of this interesting aspect and generates adequate improvements to avoid the origination of the health symptoms of auditive action. The noise levels were measured with the 1pc Sndway Decibel Meter model XXXX in some hourly, daily, weekly, monthly, seasonally and yearly periods. This numeric data is shown in table 4.

Table -4: Correlation analysis of noise levels and health of damage of auditive system of workers in the metallic industry evaluated in Mexicali in monthly periods (2023)

Time Periods, Months	Correlation Analysis				Time Periods, Months	Correlation Analysis			
	NL, dB	CHS, %	CRA, %	OY, %		NL, dB	CHS, %	CRA, %	OY, %
1	92	89	89	44	7	80	66	90	72
2	89	87	92	49	8	83	58	92	77
3	84	84	90	56	9	81	50	90	83
4	83	80	93	59	10	80	53	91	85
5	80	77	90	64	11	82	51	89	83
6	82	74	91	68	12	83	50	90	84

NL. Noise Levels (dB), 85CHS. Case of Health Symptoms, CRA. Correlation Analysis Rate, OY. Operative Yielding

Table 4 shows the correlation rate of the parameters involved to evaluate the relation between it important parameters, observing that at the begin of this investigation the higher noise levels and case pf health symptoms, with the low levels of correlation rate, indicating the relevant relation between the noise levels and the presence of diverse health symptoms mentioned above. The operative yielding percentage at the beginning of this scientific study, was low, and conforms was following this investigation was improved to reach operative yielding levels, which was pass of the 80%, being a relevant aspect in this scientific study.

3.4 Develop a Novel Automatized System to Alert About High Noise Levels

In base of the analysis made, was evaluated some specialized strategies to avoid the negative effect of the noise levels in the health of the workers of the manufacturing areas of the metallic industry evaluated. To obtain an effective result, was made a novel automatized system, to detect the high levels of the industrial equipment and machinery and a specialized function to install acoustic panels in walls to reduce the noise levels as a strategic action. With this was reduced the noise levels and the case of medical attention in the metallic industry where was made this investigation and, in the health, public medical centers of this important city of the northwest of the Mexican Republic. The automatized system is illustrated in figure 4.

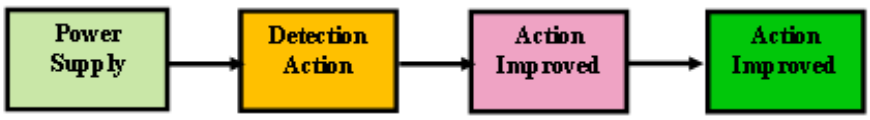


Fig -4:Steps of the automatized utilized system to reduce the noise levels

Figure 4 is a relevant diagram by steps of the automatized system to reduce the nose levels to generates an improvement to reduce the cases of the auditive health symptoms in workers that make its industrial functions in the metallic industry evaluated in 2023. The automatized system was four steps, being the first step the power supply that supply the electrical energy necessary to function the automatized system, followed by the detection action with the auditive sensors, detecting the noise levels of the industrial equipment and machinery in the metallic industry evaluated. Then, was elaborated the action improved, using the additive acoustic panels and the opening automatically of windows in some places of walls and roof of the metallic industry evaluated.

4. CONCLUSIONS

This investigation was relevant in the branch of the occupational medicine, because was observing the real state of the labor conditions of the workers of this metallic industry evaluated, where was increased the visits of the medical attention before the realization of this scientific study, where was illustrated the actual situation. This investigation open mind the conscientization of directive, managers and supervision personnel to determine the necessary improvements in the manufacturing areas, where was supported to improve the labor conditions in the industrial operations evaluated in the metallic industry where was made this scientific study. The automatized system and specialized strategies improved the labor conditions and with this, was reduced the medical visits to medical attention of workers of the industrial operations evaluated and increased the productivity and quality indices.

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