

## Diagnosis of occupational safety and health in an automotive glass manufacturing company

## Diagnóstico de seguridad e higiene ocupacional en una empresa fabricante de vidrio automotriz

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### Abstract

The objective of this study was to carry out a diagnosis of safety and hygiene in the production area of a manufacturing company to identify those factors that are the cause of occupational diseases and accidents, as well as the types of accidents and diseases that workers have suffered. The research is qualitative and was conducted with semi-structured interviews that were applied to 16 workers in the production area and data were obtained that were relevant to know the current situation with the support of the Official Mexican Standards and ISO Standards. The results were that workers have suffered accidents due to glass handling, and also diseases, due to exposure to chemicals and high temperatures. The most influential factors were lack of training and low use of personal protective equipment. It is concluded that the company has a low involvement between boss-employee and does not give continuity to these disciplines, coupled with this, possible actions were considered to pay attention to the factors detected. The study contributes to future researchers continuing with the implementation of actions that companies must carry out so that safety and hygiene is part of their daily activities.

**Occupational accident, Illness, Risk factor, Tempered glass, Production**

### Resumen

El objetivo del presente estudio fue realizar un diagnóstico de seguridad e higiene en el área de producción de una empresa manufacturera para identificar aquellos factores que son causa de las enfermedades y accidentes laborales, así como los tipos de accidentes y enfermedades que han sufrido los trabajadores. La investigación es de tipo cualitativa y se realizó con entrevistas semiestructuradas que se aplicaron a 16 trabajadores del área de producción y se obtuvieron datos que fueron relevantes para conocer la situación actual con apoyo de las Normas Oficiales Mexicanas y Normas ISO. Los resultados fueron que los trabajadores han sufrido accidentes debido al manejo del vidrio, y también enfermedades, debido a la exposición de productos químicos y altas temperaturas. Los factores que más influyeron fueron la falta de capacitación y el poco uso de equipo de protección personal. Se concluye que la empresa tiene un bajo involucramiento entre jefe-empleado y no da continuidad a estas disciplinas, aunado a esto, se consideraron posibles acciones para dar atención a los factores detectados. El estudio contribuye a que futuros investigadores continúen con la implementación de acciones que las empresas deben realizar para que la seguridad e higiene sea parte de sus actividades diarias.

**Accidente de trabajo, Enfermedad, Factor de riesgo, Vidrio templado, Producción**

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## Introduction

Most of the accidents and occupational diseases, as in the present and in the past, are due to the absence of the implementation of occupational safety and health, as well as organizations from different sectors register huge losses and inefficiency, due to the high rate of occupational diseases and injuries (Liu et al., 2020). Work-related health problems and sick leave due to occupational diseases continue to be a common problem in the European Union. (Astrom et al., 2019). In Mexico during the year 2016, 516,734 work accidents were registered in route, 12,622 people became ill due to their work activities and 1,408 people died performing their work or as a result of them (STPS, 2017).

Companies have the responsibility to provide the work environment, occupational health and safety of their employees (Astrom et al., 2019). The company where the study was carried out, the main problem is the handling of the raw material (glass) without personal protective equipment and that can cause serious accidents for this reason occupational safety aims to prevent accidents at work where risk factors exist and occupational hygiene is the main tool to eliminate, reduce and control exposure to chemical substances, biological and physical agents, by preventing and avoiding occupational diseases (Carpio et al., 2021).

According to the International Union (2001), it mentions that unsafe practices are the main cause of injuries and illnesses in the workplace and according to Heinrich's theory of accident causation, bad practices represent 88% of accidents. work accidents. According to Yiha & Kumie (2010), worldwide, 2.3 million workers die each year from occupational accidents and diseases and more than 85% of workers do not have access to health and safety services at work (Abat et al., 2019).

The International Labor Organization (ILO) mentions that every year 2.78 million workers die from work accidents and occupational diseases. Deaths and injuries caused by occupational accidents and illnesses cause a large amount of lost resources, since, globally, lost work days are estimated to represent 4% of the world's gross domestic product (GDP) and may increase to 6%. or more in some countries (Palaci et al., 2021).

Safety and hygiene problems do not seem to be a priority in companies, due to the lack of health and safety policies, deficient infrastructure and the insufficient number of personnel responsible for safety. To improve safety and hygiene, it does not mean just providing a safe environment for workers, but educating and training employees to improve their knowledge on safety and hygiene (Liu et al., 2020). The training of workers in their jobs is a fundamental preventive action to identify unsafe or deficient acts and conditions, the work environment and human behavior must be taken into account for prevention (Carpio et al., 2021). This article is important because currently many companies (mainly medium and small) do not implement safety and hygiene in production, which has caused a high number of accidents and illnesses. It is considered to continue with the awareness towards manufacturing companies and the study will set the tone to continue giving importance to implementing safety and hygiene in their workplaces, with the support of the Official Mexican Standards, where variables will be defined that will be relevant to the investigation. Which is of a qualitative type, with the application of interviews with tempered glass production workers, where it was obtained that the variables of use of personal protective equipment, training and lack of commitment are aspects that are not carried out in the company and the variables of educational level, work experience and teamwork are points that the workers and the company have developed effectively. In addition, the most frequent accidents were cuts on the body, hands and arms and burns on the arms and hands. The most frequent diseases such as: poisoning and cold due to temperature changes.

## Literature

Diseases (Occupational Diseases, OD) its acronym in English are diseases causally related to work and according to the Occupational Health Law and the Safety Law, occupational disease is any disease caused by exposure to occupational hazards. And according to the Universal Health Insurance and Security Law, occupational disease refers to temporary or permanent conditions of illness, physical or mental handicap, caused by a recurring reason due to the quality of the work performed by the worker or to the working conditions (Sen et al., 2019).

Vibrations are an occupational risk factor that can cause an occupational disease. In the Nordic countries, Canada and the United States of America, hand-arm vibration disease and its acronym in English (HAVD), means the blood circulation or nerve of the arm, which is characterized by an injury to the joint muscle of the arm, caused by continuous exposures to vibrations that are transmitted by the hand (Liu et al., 2018).

Musculoskeletal risks are also usually a risk factor in occupational accidents, where parts of the body such as the shoulder, elbow, hip, knee, neck or back can be affected (Hulshof et al, 2021) . Musculoskeletal diseases are some of the most important occupational health problems, since they are part of one of the main causes of work absenteeism in both developed and developing countries, a situation that is not alien to Mexico (STPS, 2017).

Another of the occupational hazards that can cause an occupational disease is occupational noise, which is considered the most common worldwide, since it has been reported that around 600 million workers worldwide are exposed to noise from high level, and this is related to hearing loss and also to cardiovascular diseases. Hearing loss can be prevented by using personal protective equipment (Wang et al., 2021).

The next problem that causes occupational diseases, is exposure to chemical products, has caused concern, because according to a study carried out in a Chinese province, this problem has represented more than 70% of the cases of occupational poisoning. Some of the main occupational diseases caused by exposure to solvents, according to this study are; intoxication, poisoning, dermatitis and leukemia (Dong et al., 2020) .

An important point to measure the danger of the environmental conditions to which workers are exposed, are the levels, for example, the noise level, the level of concentration of chemical products, the level of temperature in a certain area, etc. The labor force tends to be, on average, the younger and healthier population than the adult population, since risk can influence them more quickly (Lauenborg et al., 2020).

In the company where the investigation was carried out, in the production area, the most recurrent accidents were derived from contact with sharp or sharp objects, breakage of material agents, scant use of personal protective equipment, slips and falls. Most of those affected are men because they are the ones who represent the industry (Pietilä et al., 2018).

According to research, occupational health and industrial safety in small businesses is a new field and is in development. Due to this and limited resources, small businesses often do not provide health services to their workers. A study conducted in Taiwan showed that only 13% of workers in shopping center companies receive regular health monitoring examinations and 81.3% of workers in large companies do not. Studies also show that workers in small businesses are at greater risk of serious on-the-job injuries (Yang, 2013).

From a study carried out on PYMES in the city of Hermosillo, Sonora, on Safety and Industrial Hygiene, it was shown that small companies do not determine the cost of their goods based on an accident, which indicates that they are not complying with the normativity. Another important fact is that only 46% of small businesses keep a record of the events that occurred at the facilities. It can be noted that SMEs do not comply with the regulations established by the STPS, especially small companies, because they apply a smaller number of safety regulations in the industrial sector (Olguín et al., 2019).

The prevention of occupational accidents is almost always carried out by observing where they happen, in the workplace. And also It is important to have knowledge of the machinery and equipment used in the activities, since security measures made based on it must be applied (Jabbari et al., 2021).

Work-related injuries and illnesses carry significant economic costs for society, businesses, and families. These can be reduced with the help of prevention activities (Lebeau et al., 2014) . Occupational health has incorporated basic protections to the rights of workers, since the protection of life and mainly the health of workers is an important point of progress and civilization of a country (Chen et al., 2012).

## Methodology

### Context of the study

The study is of a qualitative type and the research design that is intended to be carried out in the investigation is a case study, which, most notably, is included in the study by Thomas and Znanieck (1918-1920) that deals with the Polish peasants in Europe and America, however the background for this type of research was most often conducted at the Chicago School of Sociology between the 1920s and 1950s. Stewart (2014) Creswell (2014) refers to case studies as a qualitative design (Harrison et al., 2017). This type of study will be carried out to obtain data from the production workers of a glass manufacturing company on occupational safety and hygiene. It is a small company dedicated to the manufacture of automotive tempered glass, where the main risky activity is the handling of raw material without personal protective equipment and exposure to chemical products in the screen-printing area, which is the process where it is placed. a border around the piece, according to customer requirements. Considering also that the work environment in the tempering area is risky, due to the high temperatures to which the workers are exposed, it is the process where the piece is placed in an oven to achieve the shape of a windshield or medallion, depending on the case.

### Sampling and data collection

The sample is the production area, which is divided into two areas: semi-finished and tempered. The semi-finished area, where the first manufacturing processes of the part are worked on, necessary, before moving on to the tempering process, which is the area where the piece is placed in a kiln to achieve its final shape. The total sample was 16 workers, the majority are machine operators and require the use of personal protective equipment. 16 semi-structured interviews were applied, which are made up of 17 multiple choice questions, starting with general data; name, area and job position. Continuing with the questions regarding age, schooling, experience in the position and seniority in the company and finally the questions regarding what may be the possible risk factors that cause occupational diseases and accidents. All production staff are male, and consequently, gender was not considered in the interviews. It began with the semi-finished area and concluded with the tempering area.

### Analysis of data

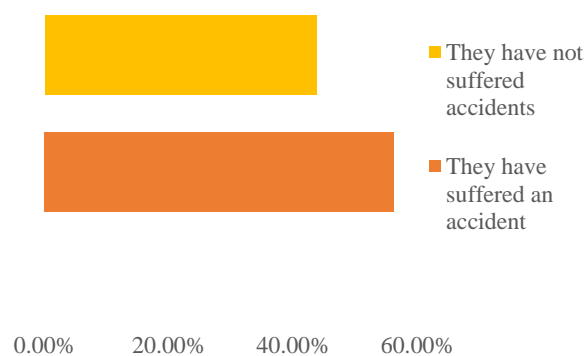
At the end of the interviews, an analysis of the responses obtained from the workers was carried out, likewise a database was created in Excel with the responses of the semi-structured interviews, which were divided into 4 categories; accidents and risks, occupational diseases, culture and procedures, and safety and hygiene, in order to obtain the current state of the company and identify those factors that affect workers and that are not being addressed by the company studied.

## Results

With respect to the semi-structured interviews carried out, the variables of greatest attention were identified, which are a factor of occupational accidents and illnesses, types of accidents and illnesses, and variables of less attention, which are carried out, but should not be stopped. to give continuity. In addition, a description of each one is made, explaining the result and the graphs of each one are shown for a better understanding. Finally, the reference standards of the STPS (Secretary of Labor and Social Welfare) that apply to the variables found are described.

### Variables of greatest attention:

**Work accidents.** Figure 1 shows the percentage of accidents in the production area, where it can be seen that 56.25% have suffered accidents at work and 43.75% have not suffered an accident. The types of occupational accidents that workers have suffered are described in figure 2.



**Figure 1** Accident rate in the production area  
*Source: Own elaboration*

**Types of accidents at work.** Different types of work accidents were detected, the main accidents were cuts, burns and crushing in the upper extremities and blows in the lower extremities, so that these are caused by the wrong handling of the glass. Each accident is described below, with the results obtained from the total number of workers who, having experienced unwanted situations, are shown in figure 2.

**Cuts for raw material handling.** In relation to the answers of the participants, 25% of the workers have suffered cuts in their hands, arms and tearing of their clothes, by not using personal protective equipment ( ppe ). The Semi-finished area is where these accidents mainly occur, due to the activity of handling raw material, which is considered risky, mainly in the first processes; loading and unloading, cutting, and polishing.

**Burns.** Burns are the most common injuries in the Tempering area, derived from exposure to high temperatures, at the time of tempering the glass, 25% of workers suffer burns on their arms daily.

**Foot blows.** To temper the glass, the loading of molds is required, the personnel does not use personal protective equipment and consequently 12.50% of the workers have suffered blows to the feet.

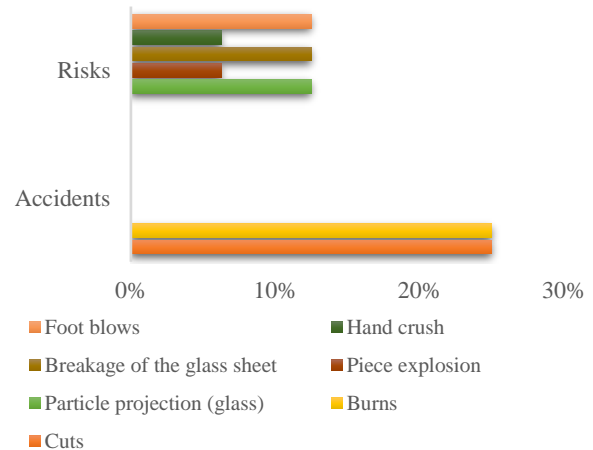
**Hand crush.** In the tempering area, 6.25% of the workers have suffered crushed hands, due to mishandling of the tempering machine or overconfidence.

**Types of occupational hazards.** Occupational risks are those to which workers are exposed daily at work, if preventive measures are not applied, they can cause unwanted situations. The risks detected are mainly related to glass handling and environmental conditions. Each of these risks is explained below, with the results obtained, shown in Figure 2.

**Cracks and breaks in glass sheets.** In the loading and unloading area (semi-finished) when handling the glass sheet, it sometimes breaks and opens. 12.50% of the workers suffer from bodily injuries and tearing of their own clothes.

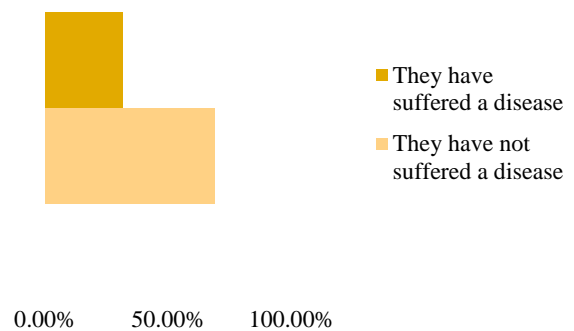
**Explosion of the pieces (glass).** When the hot pieces come out of the tempering machine, they sometimes explode due to the high temperature and because they have a defect. This has caused injuries to 6.25% of the workers.

**Particle projection (glass).** At the time of cutting the glass sheet, 12.50% of the workers have suffered injuries to the face and eyes, due to projections of glass particles.



**Figure 2** Personnel who have suffered accidents and have been exposed to risks  
Source: Own elaboration

**Occupational diseases.** Occupational diseases always exist in the work environment and consequently 31.25% of workers have become ill due to their work activities, while the rest of the workers, 68.75%, have not suffered from an occupational disease. Figure 3 shows the results obtained from the semi-structured interviews.



**Figure 3** Personnel who have suffered an occupational disease  
Source: Own elaboration

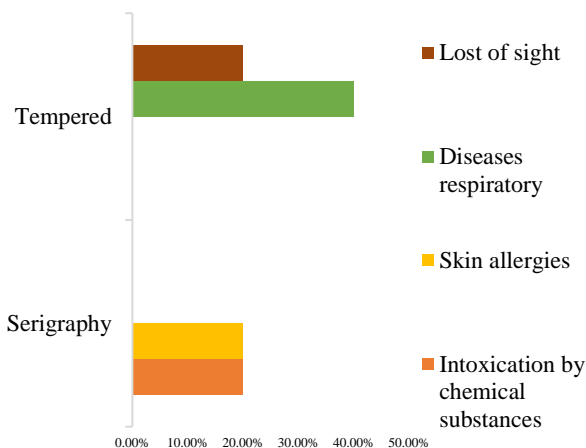
**Types of occupational diseases.** The occupational diseases that were detected are mainly due to exposure to high temperatures in the tempering area, where according to the workers the oven is between 38°C and 40°C, a very high and risky temperature for them. For the manufacturing process, it is required that the piece go through a silk-screen printing, where chemical substances are used and occupational diseases were also detected. Each type of disease is described below, with the results obtained, which are shown in Figure 4.

**Respiratory diseases .** 40% of the workers have had respiratory problems, due to the change in temperature in the Temperate area, the workers have become ill with the flu, cough and fever. Another cause of respiratory diseases is derived from fiberglass, which is inhaled in the tempering process, where the piece is placed in an oven to achieve the shape of a windshield or medallion, as the case may be.

**Loss of sight.** Workers exposed to high temperatures are suffering a loss of sight, 20% of the operators indicate that their vision is beginning to fail.

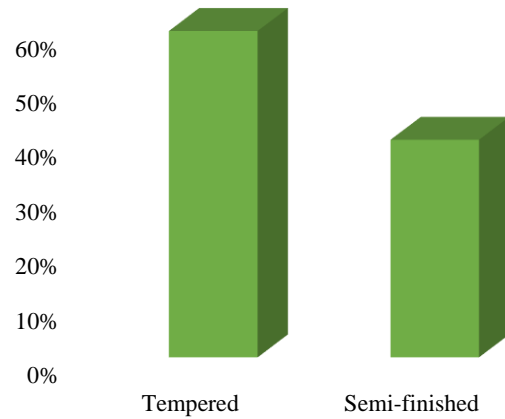
**Chemical poisoning.** In the screen-printing area, 20% of the operators have been poisoned by inhalation of thinner, due to the handling of dangerous chemical substances.

**Skin allergies.** Is caused by glass dust generated in the cutting area. 20% of workers have experienced skin allergies.



**Figure 4** Types of occupational diseases by area  
Source: Own elaboration

It is also important to know which area has had more occupational diseases in its workers and is shown in figure 5. Resulting in the tempering area with 60% of diseases and 40% for semi-finished.



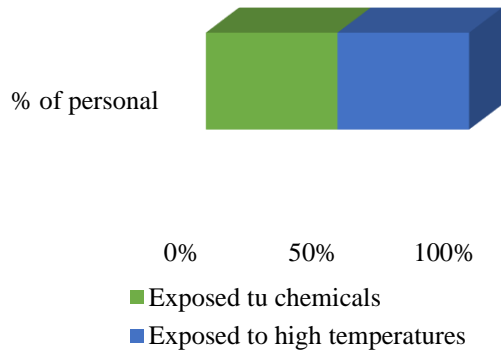
**Figure 5** Occupational diseases in the production area.  
Source: Own elaboration

**Environmental conditions.** Two main environmental conditions were detected that are a risk factor for workers, in their daily work activities, if the worker is not adequately protected, they will suffer long-term diseases. Those identified in the production area are described below.

**Exposure to dangerous chemicals.** In the screen-printing area, dangerous chemicals, solvents and thinner are used . In the quality control area, they use muriatic acid to remove paint spatter after the piece comes out of the oven. And gasoline to clean the cutting table. In 50% of workers are exposed to this type of risk factor.

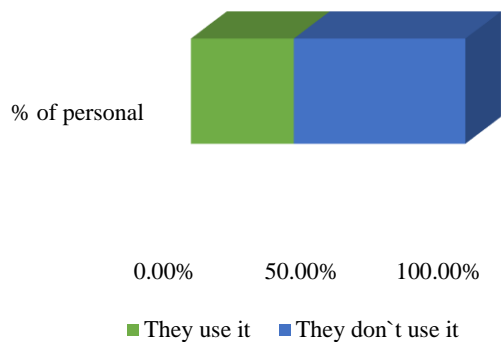
**Exposure to high temperatures.** In the tempering area, 50% of the workers are at high temperatures of approx. 40°C and the oven works at temperatures between 500°C and 700°C and changes in temperature cause illness. The following figure 6 shows the percentage of personnel exposed in the production area.





**Figure 6** Exposure to environmental conditions  
*Source: Own elaboration*

**Use of personal protective equipment.** 62.50% of the workers do not use it because they are used to it and because they find it uncomfortable to carry out their activities, or sometimes the bosses do not provide them. The workers in the semi-finished area commented that the personal protective equipment is a hindrance to carry out their activities, since they affirm that this way they carry out their work more quickly, but with the risk of suffering an accident, they live with the risk daily. 37.50% of staff do use it. These data are shown in Figure 7.



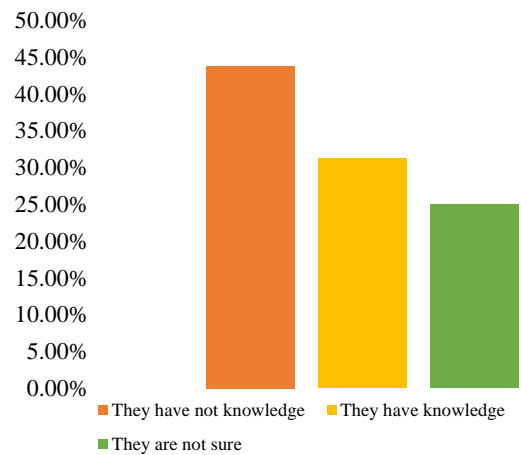
**Figure 7** Use of personal protective equipment in the production area  
*Source: Own elaboration*

**Lack of training.** It greatly influences the behavior of workers and the lack of knowledge of safety and hygiene, resulting in 68.75% of the operators have not received formal training and 31.25% indicated that they did receive training and the majority are supervisory personnel. It is shown in the following figure 8. the data obtained



**Figure 8** Training in S&H (Safety and Hygiene) for production personnel  
*Source: Own elaboration*

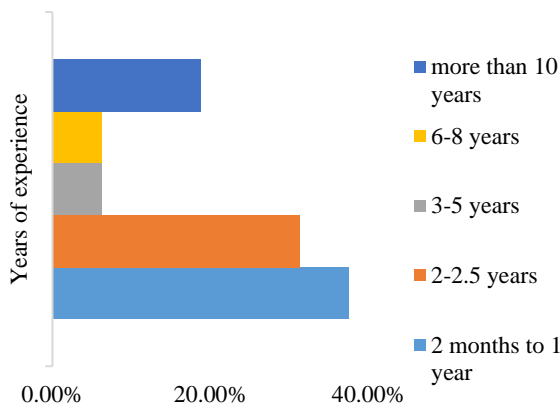
**Safety and Hygiene Procedures.** The workers are unaware that there are S&H (Safety and Hygiene) procedures. 43.75% are unaware, 31.25% are aware that they exist and 25% of workers are not sure. The workers who have knowledge are the supervisory personnel and the plant manager, however, they do not disclose it to others. Showing the percentages obtained in the following figure 9.



**Figure 9** Knowledge of S&H procedures in the production area  
*Source: Own elaboration*

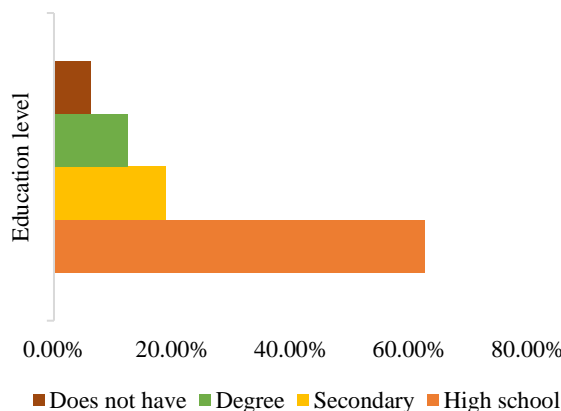
**Variables of less attention.** The variables that are important to continue with their development but that do not require further attention are the following. These variables are main requirements in all companies for their functions to be executed satisfactorily.

**Years of experience.** From the semi-structured interviews that were applied, it was detected that most of the employees have enough years of experience in the work area, in this way it is an advantage for the study, because they have the necessary knowledge to carry out their work. 37.50% of employees have experience of up to 1 year, 31.25% have up to 2.5 years in the company, 12.5% have experience ranging from 3 years to 8 years and finally 18.75% have more than 10 years in the company. Figure 10 shows the data generated by the semi-structured interviews applied to the workers of the tempered glass manufacturing company.



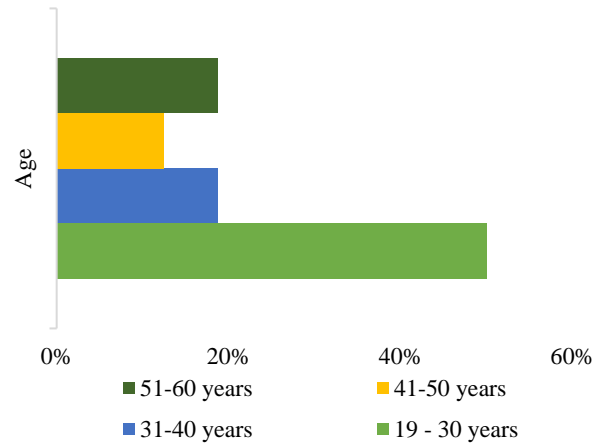
**Figure 10** Years of experience of workers in the production area  
Source: Own elaboration

**Educational level.** 62.5% of the workers have a medium educational level (high school), and are the youngest operators in the semi-finished area. The operators with a low educational level are the oldest and are in charge of the area. 12.50% have a degree and among them the plant manager and finally 6.25% have no education. Figure 11 shows the data.



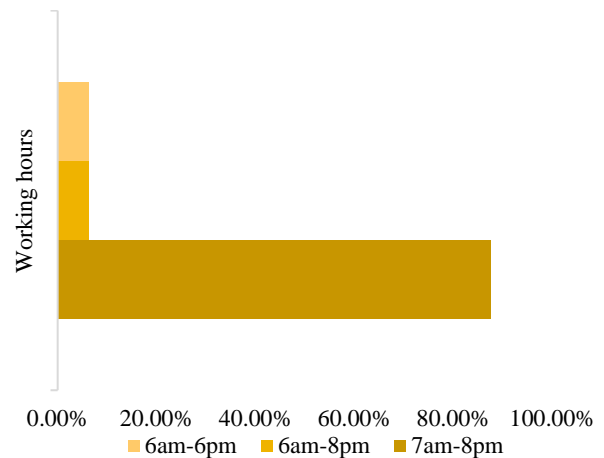
**Figure 11** Educational level of workers in the production area  
Source: Own elaboration

**Age of workers.** The age of the employees is an essential factor, because sometimes their responsibility and experience depend on it. In the case of the glass manufacturing company, 50% of the workers are young people between 19 and 30 years of age and are in the semi-finished area. The oldest are those with the most experience and range from 31 to 60 years. The following figure 12 shows the values obtained.



**Figure 12.** Age of production workers. Source: own elaboration

**Working hours.** The workers have a schedule of 12 hours or more a day, but they feel satisfied with the schedule, since they do not work 3 days a week. 87.5% work from 7am to 8pm from Monday to Thursday. Figure 13 shows the final values obtained.



**Figure 13** Working hours of production workers  
Source: Own elaboration



**Official Mexican Standards and Applicable ISO Standards**

To comply with safety and hygiene requirements, regulations must be complied with, to achieve a safe environment. The following table 1 shows the applicable regulations according to the diagnosis and the variables detected.

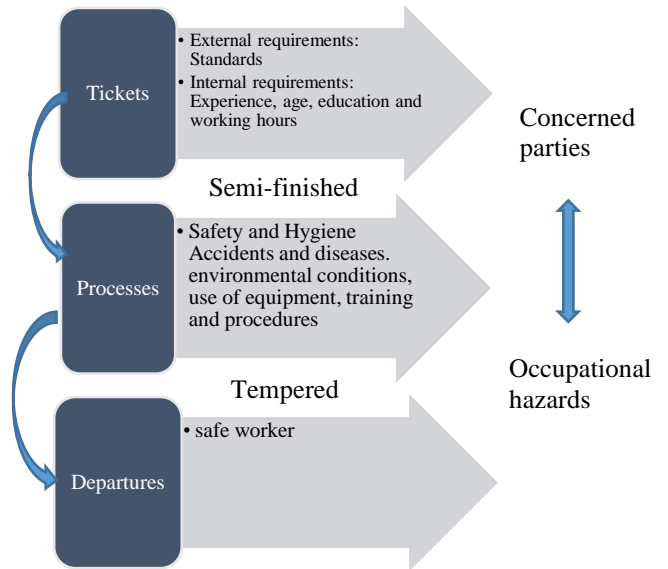
Variable	Reference norm
Cuts on fingers and hands	NOM-006-STPS-2014 (material handling)
occupational diseases	NOM-030-STPS-2009 (preventive health and safety services)
Lack of training	ISO 45001 and 18001 standards (occupational health and safety management systems)
Intoxication due to handling of chemical substances	NOM-005-STPS-1998 (handling of dangerous chemical substances) NOM-018-STPS-2015 (risk identification)
Exposure to high temperatures	NOM-015-STPS-2001 (exposure to extreme thermal conditions)
Insufficient use of protective equipment	NOM-017-STPS-2008 (use of personal protective equipment)
Ignorance of procedures	ISO 45001 and 18001 standards (occupational health and safety management systems)

**Table 1** Applicable regulations  
Source: Own elaboration

**Relationship between variables**

The variables detected are related to each other to achieve safety and hygiene in the company's production area and the following figure shows how they interrelate as a system with inputs and outputs. Where in "inputs" internal and external requirements are considered as interested parties that are the official Mexican standards and ISO standards. Internally, the company's requirements are considered for operations to function properly, which are the age of the worker, years of experience, educational level and working hours. Within the "processes" the production areas (tempered and semi-finished) were considered, where the study was carried out and there are always occupational risks if safety and hygiene are not continuously implemented. The lack of training and procedures are the basis for the worker to have the necessary knowledge about the preventive measures that must be applied at work and avoid accidents and occupational diseases.

Possible "actions" to be implemented are proposed to pay attention to the detected variables, which it is recommended that the company work together with its external and internal stakeholders, and can use tools such as: root-cause analysis, safety and hygiene audits, health campaigns, that the integration of the safety and hygiene program can be carried out. Finally, in "outputs" what we obtain is the safety of the worker and his well-being.



**Figure 14** Relationship between variables as a system  
Source: Own elaboration

The actions that are recommended to pay attention to the detected variables are the following:

- Apply preventive measures in the production area
- Provide personal protective equipment to workers on a regular basis
- Carry out continuous verifications in the production plant
- Have a medical record of each worker and carry out corresponding medical examinations
- Schedule training meetings on Safety and Hygiene
- Monitor compliance with applicable regulations

## Discussion of results

This investigation revealed that the workers of an automotive tempered glass manufacturer do not carry out 100% safety and hygiene practices in their daily activity. This is possibly due to poor safety and hygiene practices and can be attributed to low political, economic, and social commitments. Another reason may be the level of awareness of the bosses or the educational level of the participants. According to a study conducted in Iran and Nigeria, workers with a higher educational level were 6.49 times more likely to apply safety and hygiene practices than respondents with secondary and high school education, as well as professional experience (Abat et al., 2019).

Although the workers have been given instructions on safety measures, such as: use personal protective equipment ( ppe ), sometimes they lack knowledge about who to consult if they require a replacement of the equipment, or a shortage and by not having that knowledge, can lead to the acceptance of living with that risk, acts or unsafe conditions as part of their daily activities. The Temperate area, where workers are exposed to occupational diseases, are all male, consequently, men have a high burden of occupational diseases because they have a lower perception of risk compared to women ( Rikthotso et al., 2021).

According to the European Agency for Safety and Health at Work, good management requires the application of three principles: leadership, participation and commitment on the part of bosses and workers. These three principles are lacking mainly on the part of the bosses, by not training their staff, not disseminating their updated procedures and lack of commitment to provide them with personal protective equipment (Macias, 2019).

## Conclusions

After the study carried out, essential administrative and technical elements of the company under study were identified with the help of the Safety and Hygiene tools (Official Mexican Standards) and ISO Standards, which were necessary for the development of the investigation.

And the main problem addressed was addressed so that the staff can carry out their work activities in safe conditions.

The study left the following contributions:

- Identification of risks in the company, mainly the dangerous activity "handling of tempered glass". For the study it was important to know the risks to which the workers of a glass manufacturer are exposed, since they were made known to the company so that they would be in charge of implementing the necessary prevention measures in the production area. These risks exist in most manufacturers, and it is important that companies carry out a diagnosis to identify them immediately.
- The areas with the highest risk were identified. In all manufacturing companies there are areas of greater risk, according to the sector to which they belong. In this case, areas were identified, which should be paid more attention, in security measures to protect the worker.
- Awareness to bosses that employee training is important to reduce accidents and illnesses. At the end of the study, the diagnosis was made known to the employers of the company to make them aware of the variables detected with the objective of provide an immediate solution.

This research is a support for future researchers to continue with the desire to diagnose companies on Safety and Hygiene issues, and review their compliance with the Official Mexican Standards, since the production area is the place where more accidents and diseases exist. and it is relevant to mention that this study remains open for them to continue with a proposal for a safety and hygiene program or system to find out how to implement the recommended actions

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