# In-Depth Analysis of Workplace Accidents in Food Processing Company in the Philippines

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## Abstract

The study aims to investigate the causes of accidents among the food processing company in the Philippines by analyzing 82 cases of accident reports which could help in the development of preventive strategies and safety plans for companies in reducing the occurrence of workplace accidents. In order to perform an in-depth analysis of accidents, the researchers first categorized the factors associated with the accidents based gender, age, type of work, shift, extent of disability, accident type, body part affected, place of injury, nature of injury and other contributing factors. Then, statistical analysis such as Cramer's V test were performed in order to determine the significant associations among factors considered in the study. Afterwards, task analysis using Failure Mode and Effects Analysis (FMEA) is employed to determine the detailed task, percentage of responsibility and the failure points that led to the accidents. And finally, cause-responsibility analysis such as Occupational Accident Tree Analysis (OATA) and Occupational Accident Component Analysis (OACA) were used in order to determine the root causes of accidents and identify the percentage responsibility of worker and company towards the accident. The result of the analysis showed that place of injury and contributing factors were the most significant factors that led to the accident of workers. These findings helped the researchers in developing preventive strategies and safety plans for the companies to reduce occurrence of accidents in the future.

## Keywords
Workplace accidents, food processing, accident reports, safety plan

## 1. Introduction

Workplace accident is defined as the occurrence of an unpredicted accident in the workplace during the course of employments that are caused by the hazards that are inherent in, or is related to it (Baktiyari et al., 2012). These accidents are caused by various workplace factors (Khanzode et al., 2012) that resulted in loss of production, illness or injury, or damage to equipment or property (Reese et al., 2006). According to the International Labor Organization (ILO) statistics, about 317 million accidents occur at work every year, which made workplace accident a public priority (Hajakbari, 2014). Many authors have investigated the importance of workplace accidents starting from different perspectives through multiple approaches (Beland et al., 1991) and addressed workplace accidents in different workplace groups (Mearns et al., 2000; Probst, 2002; Barling et al., 2003; Rundmo and Hale, 2003; Gyekye, 2005; Håvold, 2007; Håvold and Nesset, 2009). The objective of workplace accident research is to understand accidents by obtaining accurate and objective information about the causes of accident, so that these accidents can be reduced and preventive measures can be designed (Jacinto et al., 2008 and Dotchev et al., 2008). However, the creation and application of preventive measure depends on the type of industry and their corresponding activities.

In the Philippines, data shows that within major industry group, the manufacturing industry occupies the top place and has the highest number of accidents with 23,641 (48.6% of the total) in 2013. More than one in five fatal accidents at work in the Philippines took place within the manufacturing sector, resulted to a highest percentage share compared to other sectors. Whilst, wholesale and retail trade sectors had a percentage increase of 11.8%, followed by accommodation and food service sectors with 51.85% and construction with 37.82%.

A study of Lu (2014) showed the Philippines has increasing trend of occupational injuries in terms of frequency and severity. However, due to lack of segregated information per sub-sector in the industry, exact number of accident cases cannot be identified which make it difficult to come up with preventive strategies and safety plans. Similarly, the reduction of accident in the manufacturing industry is not being studied much in the country. In the Philippines, Occupational Safety and Health Administration (OSHA), is the agency responsible for collecting data and information regarding occupational accidents, based on 2013 statistics, among all manufacturing industry, food processing has the highest number of recorded cases of workplace injury.

Thus, this paper aims to investigate the causes of accidents among the food processing company in the Philippines by analyzing 82 cases of workplace accidents in order to identify the factors that led to the accident which could help the researchers in the development of preventive strategies and safety plans for companies in reducing occurrences of accident and injuries in the future.

## 2. Methodology

The researchers collected data from food processing companies in the Philippines and a total of 82 accident reports were gathered for the study. Initially, data from the reports were categorized based on factors such as gender, age, type of worker, shift, extent of disability, type of accident, body parts affected, place of injury, nature of injury and other contributing factors in order to fully describe the demographics and profile of cases of accidents and injuries occurring in food processing companies.

Then, statistical analysis using Cramer's V test was employed in order to determine the significant relationship between associations of factors to the accident. In the study of Kurtz (1999) and Lyman et al., (1986), they stated that significant associations between levels of factors were identified by Phi coefficients following the evaluation between factors with multiple categories (Chi et al., 2006) to test the strength of association using Cramer's V. The factors associated with a significance level <0.05 made it possible to verify, with a 95% confidence level, relationship of dependence between the variables analyzed (Castrillo-Rosa et al., 2017) in the study. To process and analyze the data, the researchers used SPSS (Statistical Package for the Social Sciences V.25) software.

To further analyze the data gathered from the accident report, the researchers used Failure Mode and Effects Analysis (FMEA) in order to determine the detailed task, percentage of responsibility and the failure points that led to the accidents. And finally, cause-responsibility analysis such as Occupational Accident Tree Analysis (OATA) and Occupational Accident Component Analysis (OACA) were used in order to determine the root causes of accidents and identify the percentage responsibility of worker and company towards the accident.

## 3. Result and Discussion

Data obtained from 82 cases of accident reports were categorized and described in frequency distribution table as shown in the table 1 below.

Table 1. Frequency Distribution on Accident based on Factors

| Factor | Category | Frequency | % |
|---|---|---|---|
| **Gender** | Male | 64 | 78.0% |
| | Female | 18 | 22.0% |
| **Age** | 15-19 | 3 | 3.7% |
| | 20-24 | 21 | 25.6% |
| | 25-34 | 38 | 46.3% |
| | 35-44 | 12 | 14.6% |
| | 44-54 | 7 | 8.5% |
| | Over 55 | 1 | 1.2% |
| **Type of Worker** | Outsource | 51 | 62.2% |
| | In-house | 31 | 37.8% |
| **Shift** | Night Shift | 52 | 63.4% |
| | Day Shift | 30 | 36.6% |
| **Type of Accident** | Fall-same-level | 19 | 23.2% |
| | Struck-by | 15 | 18.3% |
| | Contacted-by | 9 | 11.0% |
| | Struck-against | 9 | 11.0% |
| | Caught-between | 7 | 8.5% |
| | Caught-in | 5 | 6.1% |
| | Caught-on | 4 | 4.9% |
| | Contact-with | 4 | 4.9% |
| | Fall-to-below | 4 | 4.9% |
| | Strain/Overexertion | 3 | 3.7% |
| | Exposure | 3 | 3.7% |

| Factor | Category | Frequency | % |
|---|---|---|---|
| **Body Parts Affected** | Upper extremities | 33 | 40.2% |
| | Head | 20 | 24.4% |
| | Torso and organs | 15 | 18.3% |
| | Lower extremities | 12 | 14.6% |
| | Back, inclusive spine and vertebra in the neck | 1 | 1.2% |
| | Neck, inclusive spine and vertebra in the neck | 1 | 1.2% |
| **Place of Injury** | Curing Area | 11 | 13.4% |
| | Meat Preparation Area | 11 | 13.4% |
| | Dispatching Area | 10 | 12.2% |
| | Packaging Area | 9 | 11.0% |
| | Processing Line | 7 | 8.5% |
| | Shipping Area | 6 | 7.3% |
| | Smoke House | 6 | 7.3% |
| | Hallway | 4 | 4.9% |
| | Repair Area | 4 | 4.9% |
| | Fabrication Area | 3 | 3.7% |
| | Freezing Area | 3 | 3.7% |
| | Comfort Room | 2 | 2.4% |
| | Canteen | 1 | 1.2% |
| | Locker Room | 1 | 1.2% |
| | Office | 1 | 1.2% |
| | Pump House | 1 | 1.2% |
| | Stock Room | 1 | 1.2% |
| | Washing Area | 1 | 1.2% |

| | | | |
|---|---|---|---|
| **Nature of Injury** | Surface wounds and bruises | 21 | 25.6% |
| | Lacerations | 19 | 23.2% |
| | Abrasions | 13 | 15.9% |
| | Avulsion | 6 | 7.3% |
| | Strain | 4 | 4.9% |
| | Contusions | 4 | 4.9% |
| | Fractures | 3 | 3.7% |
| | Punctures | 3 | 3.7% |
| | Chemical burns | 3 | 3.7% |
| | Amputations | 2 | 2.4% |
| | Eye irritation | 2 | 2.4% |
| | Enucleation | 1 | 1.2% |
| | Heat burns | 1 | 1.2% |
| **Contributing Factor** | Inappropriate education or experience | 17 | 20.7% |
| | Slippery floor | 17 | 20.7% |
| | Inadequate working method | 10 | 12.2% |
| | Lack of attentiveness | 10 | 12.2% |
| | Poor design, construction, maintenance, installation | 4 | 4.9% |
| | Exposure to chemical substances | 4 | 4.9% |
| | Insufficient/Inadequate illumination | 3 | 3.7% |
| | Handling a "difficult" object that may reduce visibility or body balance/stability | 3 | 3.7% |
| | Physical or mental stress | 3 | 3.7% |
| | Poor housekeeping and cleaning | 2 | 2.4% |
| | Deficiencies of guidelines | 2 | 2.4% |
| | Deficiencies in personal protective equipment | 2 | 2.4% |
| | Instrumentation and sensor gadgets/readers – unreliable measurement, difficult to read, or insufficient | 1 | 1.2% |
| | Difficult access to machine controls and machine parts | 1 | 1.2% |
| | Insufficient/narrow working space | 1 | 1.2% |
| | Badly maintained equipment and tools, or badly installed | 1 | 1.2% |
| | Lack of safety inspections | 1 | 1.2% |

The reports showed that majority of the victims were male (64 cases, 78.05%), aged between 25-34 years old (38 cases, 46.34%), who mostly worked as an outsourced worker (51 cases, 62.20), in the night shift (52 cases, 63.41%). The distribution of accident type among injured individuals also showed that the most common type of accidents was related to slip and fall accounted for more than 23% of all accidents while struck-by only accounted for 18% of all accidents. This was supported in the study of Lee et al. (2009) and Fabiano (2010), as stated that "falling/tumbling", in many cases associated with slip, represented always the first injury, causing accidents in the manufacturing industry. Next, the injuries (the nature of injury and part of the body injured) were most commonly surface wounds and bruises (21 cases, 25.61%) and lacerations (19 cases, 23.17%) caused damages in upper extremities (32 cases, 39.02%) and the head (19 cases, 23.17%).

## 3.1. Result of Cramer's V Test

Significant associations between all categorical factors of accidents were revealed by the Cramer's V analysis. The result is shown in the table below.

Table 2. Result of Cramer's V Test

| ALL FACTORS | Gender | Age | Type of Worker | Shift | Extent of Disability | Type of Accident | Body Parts Affected | Place of Injury | Nature of Injury |
|---|---|---|---|---|---|---|---|---|---|
| Age | 0.720 | | | | | | | | |
| Type of Worker | 1.000 | **0.061** | | | | | | | |
| Shift | 0.790 | 0.599 | 0.638 | | | | | | |
| Extent of Disability | 0.177 | 0.216 | 0.369 | 0.762 | | | | | |
| Type of Accident | **0.023** | **0.061** | **0.011** | 0.626 | **0.022** | | | | |
| Body Parts Affected | **0.033** | 0.478 | **0.042** | 0.280 | 0.558 | **0.000** | | | |
| Place of Injury | 0.569 | **0.000** | **0.009** | 0.450 | **0.014** | **0.000** | **0.000** | | |
| Nature of Injury | **0.002** | **0.000** | **0.030** | 0.226 | **0.001** | **0.000** | **0.000** | **0.000** | |
| Contributing Factor | 0.590 | **0.000** | **0.011** | 0.169 | 0.114 | **0.000** | **0.000** | **0.000** | **0.000** |

Significant associations between all categorical factors of accidents were revealed by the Cramer's V analysis. Shift was associated with place of injury and contributing factor; place of injury was associated with type of accident and contributing factor and type of accident was associated with contributing factors. Since statistical analysis mainly focused on the relationship between factors (Chi et al., 2006), they also proved on their study that using significant associations were subjected to more analysis by means of Phi coefficient and Cramer's V.

After applying Cramer's V test, it was revealed that most number of associations were found between some other factors, however only place of injury-contributing factors would be the focus for accident prevention. In other words, the multi-linear event sequence of place of injury-type of accident, type of accident-contributing factor and place of injury and contributing factor were all significant.

As shown by solid lines in Figure 1, below the listed results of causes in place of injury-type of accident-contributing factor links were the difficult access to machine controls and machine parts; insufficient/inadequate illumination; poor design, construction, maintenance and installation; exposure to chemical substances; deficiencies in personal protective equipment and poor housekeeping and cleaning are caused by type of accidents such as *Caught-in*; *Struckagainst*; *Caught-on* and *Contact-with* on the part of Dispatching Area, Pump House, Repair Area and Smoke House. Other significant type of accident-contributing factor links were insufficient/inadequate illumination with *Struckagainst* accident type in Pump House, and exposure to chemical substances and deficiencies in personal protective equipment with *Contact-with* accident type around Smoke House.

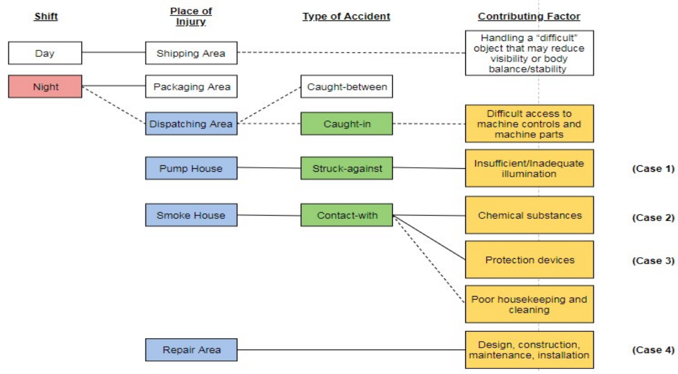


Figure 1. Place of Injury-Type of Accidents-Contributing Factor Links

On the other hand, significant associations between place of injury and type of accident and between type of accident and contributing factor does not guarantee a significant association between place of injury and contributing factor. For example, there are significant associations between Smoke House and Contact-with accident type ($\varphi = 0.578$ , $\rho = 0.024$) and between *Contact-with* accident type and exposure to chemical substances ($\varphi = 0.708$ , $\rho = 0.019$); deficiencies in personal protective equipment($\varphi = 0.499$ , $\rho = 0.038$) and poor housekeeping and cleaning($\varphi = 404$ , $\rho = 0.026$), however, Smoke House was not significantly associated with Poor housekeeping and cleaning. All these partial significant place of injury-type of accident-contributing factor links are indicated by a dotted line in Figure 1.The results also proved in the study of Näsänen and Saari (1987 and 1989) that there is a solid link between workplace housekeeping and workplace accidents.

After the method of place of injury-type of accident-contributing factor link, it can now be applied to identify the causes of workplace accidents in terms of a certain place of injury, type of accident and contributing factors' combinations. Subsequently, the results showed that place of injury and contributing factor were the most significant among all the factors, this will now be the source to identify accident causes involved in workplace accidents inside the food processing company in the Philippines. Investigating workplace accidents causes show that the most accidents can be categorized into four factors such as shift, place of injury, type of accident and contributing factors. Based on the results, insufficient/inadequate illumination, exposure to chemical substances, deficiencies in personal protective equipment and poor design, construction, maintenance, installation are significantly associated to one another resulted to having a solid line.

## 3.2. Result of Failure Mode and Effects Analysis (FMEA)

Another technique used in the study is the Failure Modes and Effects Analysis (FMEA) in order to identify all the potential failure points obtained from Task Analysis. This was employed to minimize the risk associated (Puente et al., 2002) with accidents at work and has been widely used in various manufacturing areas (Rhee et al., 2003; Dale et al., 1990). The result of FMEA indicating the accident scenario, processes, failure modes, effects, the possible root causes, and the form of multiplication of severity, occurrence, and detection of accidents is presented in the table below. The researchers applied the technique on the 4 major cases of accidents as described below.

*Case 1: Worker slipped and struck his left hand from the manual grinder*
An experienced worker was repairing SPO molding machine at Pump House when the manual grinder accidentally slipped and struck his left hand; the second case described a chemical exposure of ammonia suffered by a worker who was pouring ammonia in the oil pot causing burns on his cheeks for the reason that his thin mask was not able to

protect his face from the exposure; the third case described a worker who also suffered from exposure of ammonia and accidentally splashed both his shoulders causing him a chemical burns; and finally, the fourth case described an accident where a male worker was replacing the spiral of the Provatec machine and accidentally caught his hand on the sharp edges of the machine cover causing him an avulsion.

*Case 2: Worker caused a chemical burn on cheek while pouring ammonia*

While the 45-year old male employee is pouring ammonia in the oil pot, his thin mask was not able to protect his face from the exposure of the ammonia causing burns on his cheeks.

*Case 3: Worker caused a chemical burn on both shoulders while pouring ammonia*

A 50-year old male employee was pouring ammonia into the oil pot when accidentally the ammonia splashed and hit both of his shoulders.

*Case 4: Worker caught his hand on sharp edges while replacing the machine*

A 22 years old male employee was replacing the spiral of the Provatec machine and accidentally caught his hand on the sharp edges of machine cover causing him an avulsion.

Table 3. Result of FMEA for 4 Accident Cases

| CASE SCENARIO | PROCESS | FAILURE MODE | EFFECT | Root Cause | Severity | Occurrence | | Detection | RPN |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Score | No. of cases | Score | Score | Total |
| **Case 1:** Worker slipped and struck his left hand from the manual grinder | Get tools | Wrong tools were taken | Repair process won't continue | Tools has no label | No injury 1 | 10 | 2 | Visually 2 | 4 |
| | | Wrong specification of tools was taken | Repair process won't continue | Tools has no label | No injury 1 | 10 | 2 | Visually 2 | 4 |
| | Wear proper protective equipment | No protective equipment was worn | Employees are not allowed to enter the production area | Lack of knowledge about safety | No injury 1 | 38 | 3 | Visually 2 | 6 |
| | | Wrong protective equipment was worn | Higher risk and more prone to workplace hazards | Lack of knowledge about safety | Moderate 3 | 38 | 3 | Visually 2 | **18** |
| | Check for proper illumination | Did not check for proper workplace environment | Employees has less chance of identifying hazards and higher risk of accident | Lack of training | Moderate 3 | 47 | 4 | Quality 3 | **36** |
| | Check if it is safe to start repair | Did not check if it is safe to start the repair of the machine | Can cause failure and accident upon starting the repair | Lack of knowledge about safety | Moderate 3 | 34 | 3 | Quality 3 | **27** |
| | Repair SPO | Lack in safety knowledge when repairing machine | Can cause failure and accident upon starting the repair | Lack of training | Moderate 3 | 34 | 3 | Quality 3 | **27** |
| | | Improper procedure in repairing and testing the machine | Can cause accident both to the workers and machine operator | Lack of training | Moderate 3 | 44 | 4 | Quality 3 | **36** |
| | Gives tools | Wrong tools were given to the worker | Repair process won't continue | Tools has no label | No injury 1 | 9 | 2 | Visually 2 | 4 |
| | Seal and make sure SPO is ready for operation | Improper sealing of the machine | Can cause machine failure and occupational accident to the machine operator | Lack of knowledge about proper procedure in sealing of the machine | Moderate 3 | 11 | 2 | Visually 2 | 12 |
| | | Did not seal the machine | Machine won't be allowed to enter production | Lack of knowledge about proper procedure in sealing of the machine | Moderate 3 | 11 | 2 | Visually 2 | 12 |
| **CASE SCENARIO** | **PROCESS** | **FAILURE MODE** | **EFFECT** | **Root Cause** | **Severity** | **Occurrence** | | **Detection** | **RPN** |
| **Case 2:** Worker caused a chemical burns on cheek while pouring ammonia | Get protective equipment in the pantry | No protective equipment was taken | Won't be able to enter production area | Lack of knowledge about rules and regulations | No injury 1 | 0 | 1 | Visually 2 | 2 |
| | | Worn-out protective equipment was taken | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Company still provides worn out protective equipment | Moderate 3 | 0 | 1 | Visually 2 | 6 |
| | Make sure protective equipment are complete | Incomplete protective equipment was worn | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Lack of protective equipment provided by the company | Moderate 3 | 26 | 3 | Visually 2 | **18** |
| | | Worn-out protective equipment was worn | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Company still provides worn out protective equipment | Moderate 3 | 26 | 3 | Visually 2 | **18** |
| | Guard checks workers | Did not check for complete protective equipment | Employees will enter production with higher risk to accidents | Lack of preparing a checklist for inspection | Moderate 3 | 12 | 2 | Quality 3 | **18** |
| | Check if you have all protective equipment | Worked with an incomplete protective equipment | Guarantee exposure to ammonia that will cause burns to the employee | Lack of protective equipment provided by the company | Moderate 3 | 31 | 3 | Visually 2 | **18** |
| | | Worked with a worn-out protective equipment | Guarantee exposure to ammonia that will cause burns to the employee | Company still provides worn out protective equipment | Moderate 3 | 31 | 3 | Visually 2 | **18** |
| | Pour Ammonia in the oil pot | Improper procedure in pouring ammonia | Can cause ammonia splash that can cause burns if it contacts the body | Lack of knowledge about safety | Moderate 3 | 11 | 2 | Quality 3 | **18** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Seal the oil pot | Sealed the oil pot improperly | Ammonia can drip down cause burns to workers and product contamination | Lack of knowledge in proper procedure in sealing oil pot | Moderate 3 | 0 1 | Visually 2 | 6 |
| | | Did not seal the oil pot | Ammonia can drip down cause burns to workers and product contamination | Lack of knowledge about safety | Moderate 3 | 0 1 | Visually 2 | 6 |
| **CASE SCENARIO** | **PROCESS** | **FAILURE MODE** | **EFFECT** | **Root Cause** | **Severity** | **Occurrence** | **Detection** | **RPN** |
| Case 3: Worker caused a chemical burns on both shoulders while pouring ammonia | Get protective equipment in the pantry | No protective equipment was taken | Won't be able to enter production area | Lack in knowledge about rules and regulation | No injury 1 | 0 1 | Visually 2 | 2 |
| | | Worn-out protective equipment was taken | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Company still provides worn out protective equipment | No injury 1 | 0 1 | Visually 2 | 2 |
| | Make sure protective equipment are complete | Incomplete protective equipment was worn | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Lack of protective equipment provided by the company | Moderate 3 | 26 3 | Visually 2 | **18** |
| | | Worn-out protective equipment was worn | Higher risk and more prone to workplace hazards (e.g. chemical exposure) | Company still provides worn out protective equipment | Moderate 3 | 26 3 | Visually 2 | **18** |
| | Guard checks workers | Did not check for complete protective equipment | Employees will enter production with higher risk to accidents | Lack of repairing a checklist for inspection | Minor 2 | 12 2 | Quality 3 | 12 |
| | Check if you have all protective equipment | Worked with an incomplete protective equipment | Guarantee exposure to ammonia that will cause burns to the employee | Lack of protective equipment provided by the company | Moderate 3 | 31 3 | Visually 2 | **18** |
| | Pour ammonia in the oil pot | Worked with a worn-out protective equipment | Guarantee exposure to ammonia that will cause burns to the employee | Company still provides worn out protective equipment | Moderate 3 | 31 3 | Visually 2 | **18** |
| | Check if it is safe to pour ammonia | Improper procedure in pouring ammonia | Can cause ammonia splash that can cause burns if it contacts the body | Lack in safety procedure | Moderate 3 | 11 2 | Quality 3 | **18** |
| | | Did not check if it is safe to pour ammonia | Can cause ammonia splash that can cause burns if it contacts the body | Lack in knowledge about hazards of ammonia | Moderate 3 | 10 2 | Quality 3 | **18** |
| | | Lack in safety knowledge when pouring ammonia | Higher chance of accident while pouring ammonia | Lack in knowledge about hazards of ammonia | Moderate 3 | 10 2 | Quality 3 | **18** |
| | Seal the oil pot | Sealed the oil pot improperly | Ammonia can drip down cause burns to workers and product contamination | Lack of training and safety procedures | Moderate 3 | 0 1 | Visually 2 | 6 |
| | | Did not seal the oil pot | Ammonia can drip down cause burns to workers and product contamination | Lack of training and safety procedures | Moderate 3 | 0 1 | Visually 2 | 6 |
| **CASE SCENARIO** | **PROCESS** | **FAILURE MODE** | **EFFECT** | **Root Cause** | **Severity** | **Occurrence** | **Detection** | **RPN** |
| Case 4: Worker caught his hand on sharp edges while replacing the machine | Get tools | Wrong tools was taken | Repair process won't continue | Tools has no label | No injury 1 | 10 2 | Visually 2 | 4 |
| | | Wrong specification of tools was taken | Repair process won't continue | Tools has no label | No injury 1 | 10 2 | Visually 2 | 4 |
| | Wear proper protective equipment | No protective equipment was worn | Employees are not allowed to enter the production area | Lack in knowledge about rules and regulation | No injury 1 | 38 3 | Visually 2 | 6 |
| | | Wrong protective equipment was worn | Higher risk and more prone to workplace hazards | Lack in knowledge about safety | Moderate 3 | 38 3 | Visually 2 | 18 |
| | Make sure it is safe to remove the cover | Did not check the edges of the machine before removing the cover | Can cause cuts and scratches to the employees upon removing the cover | Lack if safety procedure about machine | Moderate 3 | 27 3 | Quality 3 | 27 |
| | | Lack in safety knowledge when repairing machine | Higher chance of accident while repairing the machine | Lack if safety procedure about machine | Moderate 3 | 27 3 | Quality 3 | 27 |
| | Replace spiral | Did not replace spiral | Machine won't be allowed to enter production | Lack of training | Minor 2 | 9 2 | Visually 2 | 8 |
| | | Improper procedure of replacing spiral | Failure in machine repair | Lack of training | Minor 2 | 9 2 | Visually 2 | 8 |
| | Cover the Provatec machine | Did not cover the Provatec machine | Supervisor | Lack of training | Minor 2 | 42 4 | Quality 3 | 24 |
| | | Improper procedure in covering the machine | Can cause cuts and scratches to machine operator and to the next worker who will fix the machine | Lack of training | Moderate 3 | 42 4 | Quality 3 | 36 |
| | Check the work done by the workers | Did not check the work done by the workers | Allowing the machine to enter production without being sure it is safe to be use | Have a checklist for machine checking | Moderate 3 | 44 4 | Quality 3 | 36 |
| | | Lack of rechecking of the supervisor | Will allow the machine to enter production by not making sure all edges of the cover is smooth, high risk of possible failure of the machine, and higher risk of accident to machine operator | Have a checklist for machine checking | Moderate 3 | 44 4 | Quality 3 | 36 |

The result of FMEA for revealed that the processes resulted to highest RPN are the following: For Case 1 - wear proper protective equipment, check for proper illumination, check if it is safe to repair and repair SPO are the processes that resulted to a highest RPN; Case 2 - make sure uniforms are complete, guard checks workers, check if you have all protective equipment and pour ammonia in the oil pot; Case 3 - make sure uniforms are complete, check if you have all protective equipment and pour ammonia in the oil pot; and for Case 4 - wear proper protective devices, make sure it is safe to remove the cover, cover the Provatec machine and check the work done by the workers.

Similarly, many studies have been conducted regarding causes of workplace accidents (Boyd, 2015; Shao et al., 2014; Cheng et al., 2013). However, fewer studies have been done on a person's/organization's role in accidents and determine the responsibility percentage using qualitative techniques (Chen and Xia, 2012). Therefore, CauseResponsibility Analysis (CRA) techniques were used in the study to determine the responsible groups and responsibility rate in an accident using two techniques such as workplace accidents tree analysis (OATA) and workplace accidents components analysis (OACA). The result of the analysis is shown in the table 4 below.

Table 4. Result of Cause-Responsibility Analysis

Case 1: Worker slipped and struck his left hand from the manual grinder

| Technique | Responsible Group | Responsibility Percentage |
|---|---|---|
| OATA | Worker | 50% |
| | Assistant Worker | 33% |
| | Company | 17% |
| OACA | Worker | 42.5% |
| | Assistant Worker | 37.5% |
| | Company | 20% |
| **Technique** | **Responsible Group** | *Responsibility Rate* |
| OATA & OACA | Worker | 46% |
| | Assistant Worker | 35% |
| | Company | 19% |

Case 2: Worker caused a chemical burns on cheek while pouring ammonia

| Technique | Responsible Group | Responsibility Percentage |
|---|---|---|
| OATA | Worker | 58% |
| | Guard | 8% |
| | Company | 33% |
| OACA | Worker | 30.0% |
| | Guard | 13.75% |
| | Company | 56.25% |
| **Technique** | **Responsible Group** | *Responsibility Rate* |
| OATA & OACA | Company | 45% |
| | Worker | 44% |
| | Guard | 11% |

Case 3: Worker caused a chemical burns on both shoulders while pouring ammonia

| Technique | Responsible Group | Responsibility Percentage |
|---|---|---|
| OATA | Worker | 63% |
| | Company | 36% |
| OACA | Worker | 57.5% |
| | Company | 42.5% |
| **Technique** | **Responsible Group** | *Responsibility Rate* |
| OATA & OACA | Worker | 60% |
| | Company | 39% |

Case 4: Worker caught his hand on sharp edges while replacing the machine

| Technique | Responsible Group | Responsibility Percentage |
|---|---|---|
| OATA | Worker | 37% |
| | Assistant Worker | 25% |
| | Supervisor | 31% |
| | Company | 6% |
| OACA | Worker | 25% |
| | Assistant Worker | 16.25% |
| | Supervisor | 52.5% |
| | Company | 6.25% |
| **Technique** | **Responsible Group** | *Responsibility Rate* |
| OATA & OACA | Supervisor | 41.8% |
| | Worker | 31% |
| | Assistant Worker | 20.63% |
| | Company | 6.13% |

The result showed that for case 1 and 2, worker has the highest responsibility rate on the cause of accident while the company has the highest responsibility rate for case 2 and supervisor for case 4.

## 3.3. Development of Safety Plan

The results discussing accidents that occurred during the operations in food processing recommended several actions to prevent similar accidents. Each case has results that brought out the importance of proper workplace instruction and guidance such as introduction to safe methods, proper use of tools and safety devices given to all employees as well as the hazards identification (Nenonen, 2011). The recommendations to improve safety in each case is given in table below.

Table 5. Recommended Safety Measures for Food Processing

| Case | Place of Injury | Contributing Factor | Event of Injury | Responsible Groups | Error Proof | Specifications | Illustrations |
|---|---|---|---|---|---|---|---|
| Case 1: Worker slipped and struck his left hand from the manual grinder | Pump House | Difficult access to machine controls and machine parts | A 39 year old male employee was repairing SPO molding machine at Pump House when the manual grinder accidentally slipped and struck his left hand. | Worker | Working with machines without a proper illumination is a basic safety procedure a worker must know. In order to avoid this type of accidents, a weekly recap of basic safety procedures must be conducted by the supervisor. Also availability of posters in the quarters of the workers reminding a few of the safety procedures. For the company's responsibility, ensuring all machinery is properly guarded and a regular check of safe workplace environment is a must. | Additional policy that the company needs is to issue headlamps to workers who will be working on area with low illumination. For the workers who will be working in the pump house, headlamps will now be advised as part of an additional protective equipment. |  |
| Case 2: Worker caused a chemical burns on cheek while pouring ammonia | Smoke House | Chemical substances | While the worker is pouring ammonia in the oil pot, his thin mask was not able to protect his face from the exposure of the ammonia causing burns in his cheeks. | Company | Looking at the result of the cause responsibility analysis, results found out that the responsible group in the accident is the company. Since the company is providing the same quality of mask to all its workers regardless of the workers task, a recommended action must provide the right specification of protective equipment in each task for the workers. In this case, if the task of the worker is to pour ammonia, mask for chemical exposure must be provided. | For the head protection, we would like to introduce a new type of mask which is the chemical safety mask. Which is designed for laboratories and chemical industry for the safety purposes. In addition to this, have a face shield guarantees that no ammonia splash will affect the workers face |  |
| Case 3: Worker caused a chemical burns on both shoulder while pouring ammonia | Smoke House | Chemical substances | A 50 year old male employee was pouring ammonia into the oil pot when accidentally the ammonia splashed and hit his both shoulder. | Worker | Proper training especially in contact with chemical substance such as ammonia is a must in the first place, but since accident is still happening, the safety plan here is to add posters inside the Smoke House that contains illustrations, proper procedure and warning signs on what will be the effect of ammonia to our skin if it is not properly use. For this reason, workers will be extra careful and apply the training they got from pouring ammonia. | Additional posters raises the awairness of the workers when pouring ammonia. This sample posters shows what are the must have protective equipment when handling chemicals. The poster also shows the effects a person may acquire once in contact with a chemical |  |
| Case 4: Worker caught his hand on sharp edges while replacing the machine | Repair Area | Design, construction, maintenance, installation | A 22 year old male employee was replacing the spiral of the provatec machine and accidentally caught his hand on the sharp edges of machine cover causing him an avulsion. | Supervisor | In this event of injury, the person responsible is the Supervisor. Looking back to the root cause of the problem, it is the task of the supervisor to make sure that there must be no sharp edges in the machine in the first place. A preventive plan for this is to have a machine guarding checklist for all assigned supervisors to ensure machine guards remain in place and are functional, train employees on specific guard rules in their specific areas and immediately correct deficiencies. | Supervisors must be reminded on how to properly check machines after its repair. Adittional guidelines must be prepared for the supervisor to remember how to properly check a machine | |

In the attempt to prevent human error from occurring in the workplace, pre- and post- task safety reviews should be implemented. This is mostly applicable to Case 1 and Case 4 wherein, this approach helps by informing, involving, and engaging workers to be more aware of the tasks to be performed, their hazards and risks, and the presence of error traps or precursors (Wachter et al., 2014). Most of these tools work by improving the worker's sense of awareness. From the study of Rich et al., (2010), responsible groups should have enhanced their performance by allowing them to continually learn and adapt from their work situations in order to be more aware with deficiencies within or changes occurring in the workplace as they are the one who are more focused on responsibilities and emotionally connected to the tasks that constitute their role (Wachter et al., 2014). This mediates by "improving" the performance of the safety management system and increasing safety outcome performance due to its effectiveness in dealing deficiencies.

Similarly, the concept of a prevention culture is implicitly use to Case 2 and Case 3 also stated in table above based on the concept of a safety culture. The difference between prevention and safety culture is the latter aims to reduce work-related risks and mostly address workplace level that is found mainly in high-risk industries and emphasized on the protection of health, whereas the former emphasizes both the protection and promotion of health (Kim et al., 2016), and requires to reduce risks in the workplace level by promoting technological improvements, compliance with regulations and labor inspections, and introduction of an occupational safety and health management system, as well as managed culture change to achieve a positive safety culture. This also includes workers at all workplaces.

## 4. Conclusion

The study applied statistical analysis and cause-responsibility analysis on 82 cases of accidents in a food processing company to evaluate causes associated with all the factors given. A complete coding and classification was developed to analyze and coded each accident in terms of the victim's age, gender, the type of worker, shift, place, type and nature of injury, body parts affected and contributing factors. Similar to the study of Chi et al., (2017), coding scheme was able to identify factors contributing to the accidents. Contributing factors such as insufficient/ inadequate illumination, exposure to chemical substances, deficiencies in personal protective equipment and poor housekeeping and cleaning mostly have damaging effects on the workplace accidents were associated with place and type of injury derived through analysis of Cramer's V by applying multi-linear event sequencing method. With the support of the practical information and tools of Task Analysis, FMEA and Cause-Responsibility Analysis, identification of hazards, determination of accident causes, responsible groups and their role on accident as well as the responsibility rate (Jabarri et al., 2016) were determined to enhance safety of workers. As a result of using Cramer's V as well as the CRA technique on the 82 cases the results confirmed that the study was well applicable to achieve the objectives of the research. For responsible groups involved, the analysis of this research can be useful as a way of adding relevant knowledge to the management of workplace safety (Carillo-Castrillo et al., 2013) and can be used among other risk assessment, preventive plan and safety measures in any food processing company. Future researches may be extended to assess the effectiveness of these tools by developing Probabilistic Risk Assessment and Fault Tree Analysis approach particularly on the analysis of accidents.

## References

Amorim, G., and Pereira, C.M. "Improvisation at workplace and accident causation - an exploratory study," Procedia Manuf., vol. 3, no. Ahfe, pp. 1804–1811, 2015.

Bakhtiyarim M., Delpisheh, A., Riahi, S., Latifi, A., Zayeri, F., Salehi, M., and Soori, H., "Epidemiology of occupational accidents among Iranian insured workers," Saf. Sci., vol. 50, no. 7, pp. 1480–1484, 2012.

Barlas, B., and Izci, F.B., "Individual and workplace factors related to fatal occupational accidents among shipyard workers in Turkey," Saf. Sci., vol. 101, no. October 2016, pp. 173–179, 2018.

Carrillo-Castrillo, J., Onieva, L., and Rubio-Romero, J., "Causation of severe and fatal accidents in the manufacturing sector," Int. J. Occup. Saf. Ergon, vol. 19, no. 3, pp. 423–434, 2013.

Castillo-rosa,J., Suárez-cebador,M., Rubio-romero,J. and Aguado, J., "Personal factors and consequences of electrical occupational accidents in the primary, secondary and tertiary sectors," Saf. Sci., vol. 91, pp. 286–297, 2017.

Cheng, C., and Wu, T., "An investigation and analysis of major accidents involving foreign workers in Taiwan's manufacture and construction industries," Saf. Sci., vol. 57, pp. 223–235, 2013.

Chi, C., Yang, C., and Chen, Z., "In-depth accident analysis of electrical fatalities in the construction industry," Int. J. Ind. Ergon., 2009.

Chi, C., Chang, T., and Hung, K., "Significant industry – source of injury – accident type for occupational fatalities in Taiwan," vol. 34, pp. 77–91, 2004.

Doytchev, D. E., and Szwillus, G. "Combining task analysis and fault tree analysis for accident and incident analysis: A case study from Bulgaria," vol. 41, pp. 1172–1179, 2009.

Golinescu, R., Morosan, F., and Kazimi, M., "A probabilistic methodology for the design of radiological confinement of tokamak reactors," Reliab. Eng. Syst. Saf., vol. 58, no. 3, pp. 275–296, 1997.

Hintikka, H., "Accidents at work during temporary agency work in Finland – Comparisons between certain major industries and other industries," Saf. Sci., vol. 49, no. 3, pp. 473–483, 2011.

Hoła, B., and Szóstak, M., "An Occupational Profile of People Injured in Accidents at Work in the Polish Construction Industry," in Procedia Engineering, 2017.

Ja, C. and Onieva, L., "Organizational causes of accidents in manufacturing sector". pp. 587–594, 2012.

Jabbari, M., and Ghorbani, R., "Developing techniques for cause-responsibility analysis of occupational accidents," Accid. Anal. Prev., vol. 96, pp. 101–107, 2016.

Jacinto, C., Canoa, M., and Soares, C., "Workplace and organisational factors in accident analysis within the Food Industry," vol. 47, pp. 626–635, 2009.

Jørgensen, K., "Prevention of 'simple accidents at work' with major consequences," Saf. Sci., vol. 81, pp. 46–58,2016.

Kim, J., "The Relationship Between Frequency of Injuries and Workplace Environment in Korea: Focus on Shift Work and Workplace Environmental Factors," Saf. Health Work, 2018.

López-Arquillos, A. and Rubio-Romero, J., "Analysis of Workplace Accidents in Automotive Repair Workshops in Spain," Saf. Health Work, vol. 7, no. 3, pp. 231–236, 2016.

Lortie, M. and Rizzo, P., "The classification of accident data," Saf. Sci., vol. 31, no. 1, pp. 31–57, 1998.

Matsuoka,Y. and Fukushima,M., "Time zones, shift working and international outsourcing," Int. Rev. Econ. Fin., 2010.

Nenonen, S., "Fatal workplace accidents in outsourced operations in the manufacturing industry," Saf. Sci., vol. 49, no. 10, pp. 1394–1403, 2011.

Patwary, M., W. T. O. Hare, and M. H. Sarker, "Occupational accident: An example of fatalistic beliefs among medical waste workers in Bangladesh," Saf. Sci., vol. 50, no. 1, pp. 76–82, 2012.

Picchio, M. and Van Ours, J., "Temporary jobs and the severity of workplace accidents," J. Safety Res., vol. 61, pp. 41–51, 2017.

Pietilä, J., Räsänen, T., Reiman, A., Ratilainen, H. and Helander, E., "Characteristics and determinants of recurrent occupational accidents," Saf. Sci., no. April, pp. 0–1, 2017.

Pillay, M., "Accident Causation, Prevention and Safety Management: A Review of the State-of-the-art," Procedia Manuf., vol. 3, no. Ahfe, pp. 1838–1845, 2015.

Salguero-Caparros, F., Suarez-Cebador, M. and Rubio-Romero, J., "Analysis of investigation reports on occupational accidents," Saf. Sci., vol. 72, pp. 329–336, 2015.

Saric, S., Bab-Hadiashar, A., Hoseinnezhad, R. and Hocking, I., "Analysis of forklift accident trends within Victorian industry (Australia)," Saf. Sci., vol. 60, pp. 176–184, 2013.

Yi, K. and Lee, S., "A Policy Intervention Study to Identify High-Risk Groups to Prevent Industrial Accidents in Republic of Korea," Saf. Health Work, vol. 7, no. 3, pp. 213–217, 2016.

Wachter, J. and Yorio, P., "A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation," Accidents Anal. Prev., vol. 68, pp. 117–130, 2014.

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