Supply Chain Risk Assessment of Hazardous Chemical Products in a University Laboratory

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Abstract

University laboratories own distinctive and significant risk conditions that can possibly expose staffs and students to chemical and physical hazards, including process risks. Apart from practicing safety measures, it is important for the universities to assess and improve controllable risks in accordance to statutory policies and regulatory procedures, from authorized Safety and Health associations both locally and internationally. Hence, the study explores the processes in inventory management starting from ordering, storing/handling and on-site transporting. Identification of contributing risks in the laboratories is structured through Hazard and Operability (HAZOP) Analysis and Decision Matrix Risk Assessment (DMRA) technique for the estimation of risks to be prioritized. The results obtained from Wilcoxon test showed that one factor contributed significantly to hazards and risks associated with inventory management: "use of standard procedures for any possible emergency/uncertainties". Through the derived risk threshold value of 7, three factors are determined to be mitigated, (1) segregation of hazardous chemicals according to their classification, (2) elimination of unnecessary, unused, and outdated hazardous chemicals, and (3) delay in the delivery from supplier. A risk treatment matrix plan is then proposed and developed as a guideline in controlling and managing the risks they are by-chance exposed to.

Keywords
Risk Assessment, University Hazardous Chemicals, Risk matrix, HAZOP, DMRA

1. Introduction
Chemical industry is known to be structured, yet, there is still a lack of presence for hazard precautions about hazardous substances and the commodities which are used. Chemicals are hazardous substances and problems regarding the purchasing, procurement, receiving, and transportation to safety is necessary to address. Having such small amounts of hazardous substances used by academic laboratories, people tend to mislead the risks attached to them compared to large chemical industries. (Olewski and Snakard, 2017). However, laboratory staffs and students are still exposed in chemical and physical hazards of those chemical substances that could further be seen in short and/or long term. (Marendaz et al., 2013). In fact, those sectors that are considered to be part of the small-scale chemical industry, particularly for institutions with laboratories, have revealed to be much more relaxed of their process hazards leading to unprepared safety hazards, environmental disasters, chemical-related accidents, and worst even more are the fatalities connected. (Olewski and Snakard, 2017). Hence, risk assessments must be conducted for all activities in the supply chain, which involves the use, transport, storage and disposal of hazardous chemicals, as risk assessment promotes efficiency, fewer incidents, and minimization of costs.

Numerous chemicals have its own type of hazards and risks levels that are exposed to the concerned users. It is indeed critical for the suppliers, manufacturers, and end-consumers to provide the necessary information to prevent from any disruptions. (Karimi et al., 2017).

1.1 Objectives
The purpose of this study is to assess the risks involving inventory management processes of hazardous chemical products in the laboratories using HAZOP-DMRA and derive a risk threshold that will act as a risk evaluation criterion to quantitatively support the organization in estimating risks in inventory of the hazardous chemicals. Additionally, the study aims to help mitigate the risks through establishing a risk treatment matrix plan engineering solutions, tools, and analysis.

2. Literature Review
Hazardous chemical substances are related to a wide range of health hazards (such as irritation, sensitization, and carcinogenicity) and physical hazards (such as flammability, corrosion, and explosibility). In order to sustain chemical safety in the workplace, information about the identities and hazards of the chemicals must be accessible and understandable. (OSHA, 2020)

Government Regulations and Implementation for Chemicals in the Philippines, the Bureau of Working Conditions (BWC) is connected to the Department of Labor and Employment (DOLE) in terms of performing policy and program development. The Occupational Safety and Health Center of the DOLE-BWC established a standardize local handbook that serves as a guidance and compliance in all safety and security concerns. For international guidelines, organizations focus on different aspect but are established to create standards in protecting every industry to harmful substances, especially hazardous chemicals. The following organization provide guidelines, policies, procedures and standards that can be applied universally: Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), Globally Harmonized System (GHS) of Classification and Labelling of Chemicals

Challenges related to Hazardous Chemicals and Safety in university laboratories is often associated with a lack of safety awareness. According to Al-Zyoud et.al. (2019), procedures must be placed by the facility to ensure that pain and suffering resulting from all occupations, exposures, and accidents are minimized. Small-scale chemical laboratory research and teaching activities tend to operate independently and have less government and regulatory oversight. It is the responsibility of the University and its employees to be well-informed regarding hazardous chemicals and the risks associated with using them in the laboratory. It is their job to appropriately assess the risks of what they are doing, how to appropriately assess changes in risks if a key experimental parameter is changed, or how to keep a small error from getting out of control.

The application of Human–Technology–Organization (HTO) interaction is important to account in risk management, since workplace accidents are usually caused by a combination of these factors: (1) Human factors: attitudes; safety culture; current fitness. (2) Technical factors: according to work tasks and requirements, e.g., expertise. (3) Organizational factors: the absence of rules; induction; training. Applying the concept of HTO provides a better all-round view. (Näslund and Engström, 2017). Following the implementation of risk assessment, action plans should be improved. Prioritize and plan measures according to the degree of severity.

Risk Threshold
The risk threshold is an amount of risk that an organization or individual is willing to accept. The organization will not tolerate the risk that are exceeding the threshold. (Usmani, F. 2020).

3. Methods
Hazard and Operability Analysis (HAZOP)
HAZOP is a structured and comprehensive technique particularly used to the identify the hazards entailed in the processes. A set of guide words are introduced to add value with system parameters that would then identify the discrepancies from the said problems.

Table 1. HAZOP recording form as standardized in IEC Standard 61882-2016.

No.	Guide word	Element	Deviation	Possible Causes	Consequences	Safeguards	Comments	Action required	Assigned to
Assign each entry a unique tracking number	Insert deviation guide word used	Describe what the guide word pertains to (material, process, step, etc.)	Describe the deviation	Describe how the deviation may occur	Describe what may happen if the deviation occurs	List controls (preventive or reactive) that reduce deviation likelihood or severity	Capture key relevant rationale assumptions, data, etc.	Identify any hazard mitigation or control actions required	Record who is responsible for actions

Table 1 is the standard template for the HAZOP examination regulated by International Electrotechnical Commission International Standard IEC 61882-2016, (2016). However, since HAZOP is not limited only to potential risk investigation of processes, several amendments to the template have been made and developed according to the type and complexity of the industry, and the preference of the team that will analyze risks using HAZOP.The application of Normality Test will support in the determination if the P-Value of the set of data is <0.05. Through t-test, the researchers tested if the respondents' perceived acceptance to risks is significantly greater than the respondents' average working experience.

Descriptive Statistical Data Analysis
The researchers analyzed the set of data using descriptive statistical analyses of Mean, Median, and Mode to identify the risk threshold. Risk threshold will be derived from the generated values of the median and mode whereas the median is the middle value or "true center" of the data, and the mode which indicated the value that occur most frequently in the data.

Wilcoxon Signed Rank Test
In order to determine the significant factors contributing to risks in the inventory management processes, the researchers used Wilcoxon Signed Rank test. The analysis is a non-parametric test since the data is not normally distributed.

Decision Matrix Risk Assessment (DMRA) Technique

		Consequence →				
		1 (Insignificant)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Very Significant)
Likelihood →	5 (Almost Certain)	5	10	15	20	25
	4 (Likely)	4	8	12	16	20
	3 (Possible)	3	6	9	12	15
	2 (Unlikely)	2	4	6	8	10
	1 (Rare)	1	2	3	4	5

where:

R: Risk factors
R: **15 to 25 = High Risk**, immediate and detailed action for protection is necessary.
R: **10 to 12 = Significant Risk**, monitor and take precautions on the risks involved.
R: **5 to 9 = Moderate Risk**, monitor and take precautions on the risks involved.
R: **1 to 4 = Low Risk**, no further action necessary and can be managed.

Table 2. Risk Matrix Template based on the Office for the Institutional Planning and Policy Development, AdU

In order to evaluate the risks, the researchers utilized the DMRA method to determine the impact of the risks through its frequency of occurrence and severity. According to Dominguez et al., (2019), a systematic approach will serve as the guide in the prioritization of the most severe risk to the least severe risk. Table 2 shows the Risk Matrix template that was used by the Adamson University in terms of assessing the identified risk

Table 3. Probability of Risks Encountered

Likelihood	Level of Risk	Description (Operational)
5	Almost Certain	At least once a week (1-7 days)
4	Likely	Could happen at least once a month but not weekly (8-31 days)
3	Possible	Could occur once per quarter but not monthly (32-90 days)
2	Unlikely	Only in exceptional/rare circumstances (91-365 days)
1	Rare	Has not happened in any circumstance within the year (0 or >365 days)

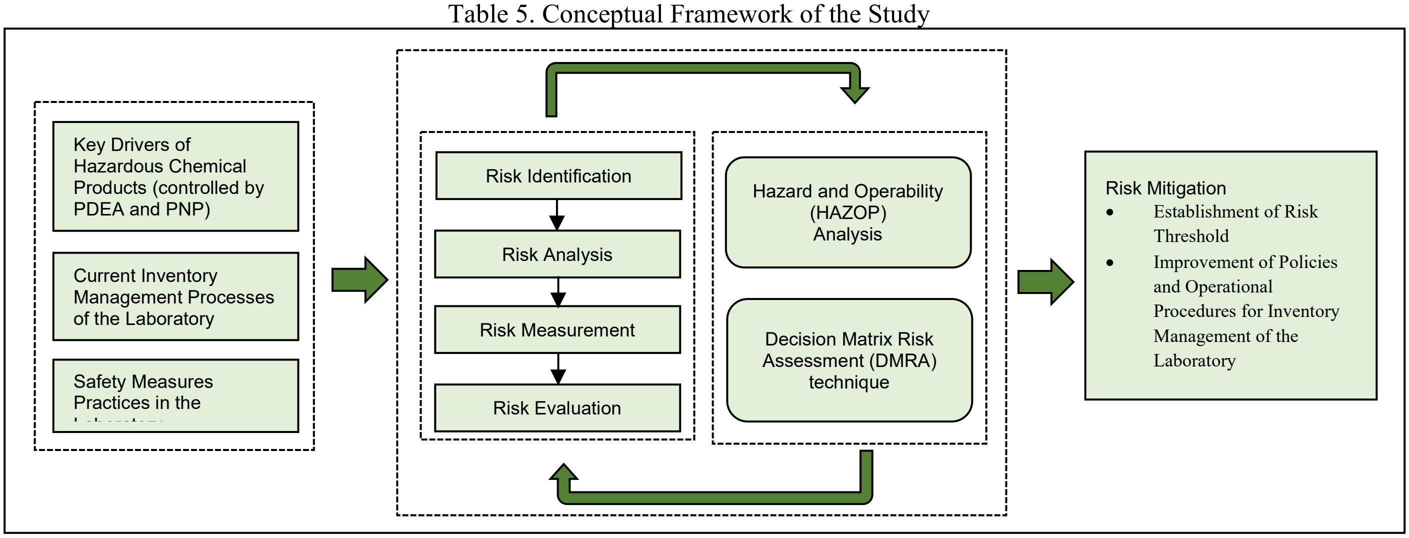
Table 4. Perceived Severity of Risk

Severity	Level of Risk	Description	Health and Safety
5	Very Significant	A risk that would create catastrophic impact in large portion of the laboratory for long-term; permanent injuries, irrelevant health effects affecting the operations, employees, organization	Death
4	Major	A risk that would cause massive impact on the quality of services provided by the laboratory affecting the operations, employees, organization	Permanent Disability
3	Moderate	A risk that happens greatly, affecting the flow of laboratory operations, employees, organization	Partial Disability
2	Minor	A risk that could happen on the quality of services resulting to some encounter of issues/complaints in the organization	Temporary Disability
1	Insignificant	A risk that could give negligible adverse effects on the flow of laboratory operations, employees, organizations	Minor Injuries

Table 3 shows the descriptions for the occurrence and Table 4 shows the perceived severity of risks encountered by the respondents in the inventory management of the laboratories. The rating stated has specific impacts and descriptions according to the occurrence or severity.

4. Data Collection

Table 5. Conceptual Framework of the Study



In Table 5 the conceptual framework of the study is defined as the following: (1) Key Drivers of hazardous chemical products, specifically PDEA and PNP controlled chemicals; (2) Current inventory management process in the laboratory; and (3) the safety measures practices in the laboratory. The inputs will run through the risk assessment process of identification, analysis, measurement, and evaluation, using different statistical analysis tools, HAZOP study, and DMRA method. The outputs of the study are mitigation of risks, including establishment of risk threshold, improvement of policies and guidelines through the development of risk matrix plan for the inventory management of the laboratory.

Sampling and Survey Instrument

The survey questionnaire contains five different parts: (1) demographic profile of the laboratory personnel and student assistants, (2) Exposure of laboratory staffs to specific hazardous (controlled) chemical substances, (3) Inventory management practices that the university was regulating in the laboratory, (4) likelihood and severity of risks in the inventory management, and (5) the acceptance of risks of the employees in inventory of hazardous chemicals. The ratings provided a 5-point scale whereas 1 = Lowest and 5 = Highest; The sample size has a total of 22 respondents since the sampling approach used was a non-parametric sampling called Purposive Sampling.

5. Results and Discussion

The respondents gathered based from the laboratories were from the Chemistry with 12 (55%), 5 (23%) in Chemical Engineering, 3 (14%) in Pharmacy and 2 (9%) respondents were from Biology. The frequency of respondents according to their job designation also showed that 4 (18%) out of 22 were Head or Coordinator who administer and supervise the laboratories, 5 (23%) were Laboratory Staffs who were assigned in different areas in the laboratories, 6 (27%) were Laboratory Instructors or Faculty Members who educate students, and 7 (32%) were Student Assistant, or students who helps in maintaining and managing the laboratories.

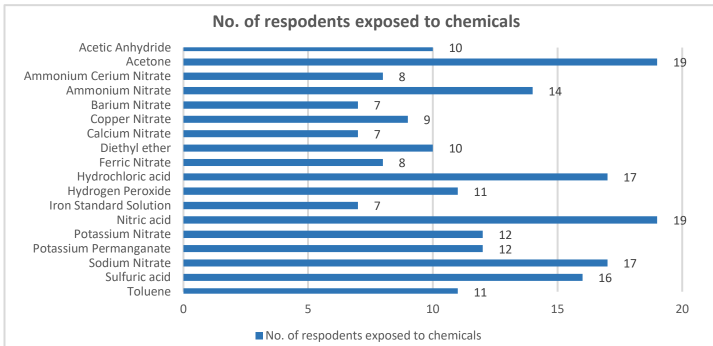


Figure 1. Exposure frequency of laboratory employees to hazardous chemicals

Based on the summarized result shown in Figure 1, it was observed that the Acetone and Nitric Acid ranked highest in chemicals that people are commonly exposed to, having 19 respondents exposed to, followed by Hydrochloric acid and Sodium Nitrate with 17 respondents, Sulfuric acid with 16 respondents exposed to, followed by Ammonium Nitrate with 14 respondents.

Table 6. Preliminary HAZOP Analysis for On-Site Transportation Process

Preliminary Hazard and Operability (HAZOP) Analysis Record Sheet						
Project Title:	**INVENTORY MANAGEMENT OF HAZARDOUS CHEMICALS IN THE LABORATORY**				*Sheet No.:* ***1***	
Members:					*Date Completed:*	
Process:	**STORING AND HANDLING PROCESS OF HAZARDOUS CHEMICALS**					
No	**Guideword**	**Element/Parameter**	**Deviation**	**Possible Causes**	**Consequences**	**Safeguards**
1A	Not done	Segregating of chemicals	Segregation according to chemical classification is not done	Inadequate storage space and area	Improperly segregated chemicals can create unwanted reactions, like heat, fumes, gases and vapors generation which can lead to a fire or explosion	Create adequate spaces for storage, especially for chemicals required to segregation
1B	Not done	Segregating of chemicals	Segregation according to chemical classification is done in an incorrect way	Warnings and data sheets are not thoroughly reviewed	Violent chemical reactions can cause physical injuries and a lot of property damage	Review warning signs and MSDS before proceeding in storing
2A	Less	Chemical containment, storing systems and equipment	Storing according to chemical containment, storing systems (e.g., racks, and cabinets) and equipment is limited	Not working, damaged, deteriorating, or leaking containers, storing systems and equipment	Corrosion in metal shelves as metals corrode when exposed to acids, if using wood shelves, spill of oxidizer may result to fire	Use the required containment, storing systems and equipment of chemicals to prevent unwanted chemical reactions
2B	Less	Chemical containment, storing	Storing according to chemical	Deficient protective	Health and safety at stake as accidental	Use additional protective

		systems and equipment	containment, storing systems (e.g., racks, and cabinets) and equipment is limited	secondary hazard-resistant containment system used	spills, leaks, and release of chemical might produce	containment especially for corrosive and reactive chemicals; Always prepare a spill kit
3A	Part of	Labels in chemicals	Partly added labels in the chemical containers	Operator error – not able to put all necessary label for the chemical bottles, containers, or storage	Accidents, injuries, unintended mixing of chemicals, or inappropriate handling	Clearly label all chemicals, if possible, put the label in every corner of the container
4A	Less	Warning signage	Inadequate visual warnings and signage	Lack of installed visible warnings and signage around the storage	Chemical accidents might happen due to lack of warning signs	Install all necessary warning signs wherever possible and visible

Table 7. Preliminary HAZOP Analysis for On-Site Transportation Process

Preliminary Hazard and Operability (HAZOP) Analysis Record Sheet						
Project Title:	**INVENTORY MANAGEMENT OF HAZARDOUS CHEMICALS IN THE LABORATORY**					*Sheet No.:* ***2***
Members:						*Date Completed:*
Process:	**ON-SITE TRANSPORTATION PROCESS OF HAZARDOUS CHEMICALS**					
No	**Guideword**	**Element/Parameter**	**Deviation**	**Possible Causes**	**Consequences**	**Safeguards**
5A	Less	Warning signage	Inadequate visual warnings and signage	Lack of installed visible warnings and signage around the transporting area	Chemical accidents and injuries might happen due to lack of warning signs	Install all necessary warning signs wherever possible and visible;
6A	Not done	Segregating of chemicals	Segregation according to chemical classification is done in a incorrectly done	Warnings and data sheets are not thoroughly reviewed	Violent chemical reactions can cause injuries and a lot of property damage	Review warning signs and MSDS before proceeding in the transport
7A	Part of	Labels in chemicals	Inadequate labels in the chemical containers	Operator error – not able to put all necessary label for the chemical bottles, containers, or trays	Accidents, injuries, unintended mixing of chemicals, or inappropriate handling	Create and put an “initial” but proper label in the containers before transporting
8A	Less	Chemical containment, transporting tools and equipment	Limited use or not properly utilization of chemical containment, transporting tools and equipment	Carrying chemicals by hand, or crowding of chemicals in a single containment, tool and equipment,	Health and safety at stake as accidental spills, leaks, and release of chemical might produce	Use the required containment, transporting equipment for chemicals to prevent unwanted chemical accidents; Always prepare a spill kit

Table 8. Preliminary HAZOP Analysis for Ordering Process of Chemicals

Preliminary Hazard and Operability (HAZOP) Analysis Record Sheet						
Project Title:	**INVENTORY MANAGEMENT OF HAZARDOUS CHEMICALS IN THE LABORATORY**					*Sheet No.:* ***3***
Members:						*Date Completed:*
Process:	**ORDERING PROCESS OF HAZARDOUS CHEMICALS**					
No.	**Guideword**	**Element/Parameter**	**Deviation**	**Possible Causes**	**Consequences**	**Safeguards**
9A	Other than	Purchase order process	Other than the Purchase order	Lack of awareness to the ordering process system	Miscommunication between all personnel	Conduct team meetings about

			process was fulfilled			the inventory rules and process
10A	Other than	Placing order	Information other than the required was done in placing order	Incorrect item information placed upon filling the purchase order	Wrong item classification (e.g., kind, unit, volume) can be delivered	Review all item information before placing order
11A	Late	Delivery of item	Delay in the delivery of items	Wrong forecasting method was used in the inventory	Shortage of item in the inventory	Determine the lead time of each item to be ordered

Tables 6-8 shows the Preliminary HAZOP Analysis of the three different inventory management process of hazardous chemicals, namely, storing or handling process, on-site transportation process, and order processing, respectively.

5.1 Numerical Results

Based from the result of p-value, 0.120 is normal, providing stronger evidence that data will reject the null hypothesis. The respondents' perceived acceptance to risks is significantly greater than the respondents' average working experience of 5.5 years. Through further analysis, the researchers associated the working years-experience of the respondents to their perception to risks. As the working years-experience increases, the awareness of the respondents to risks present in the workplace is also increasing. Moreover, according to the study of Fadlallah et al., (2020), one of the indicators and determinants of perceived risk among miners is "Years of work" and concluded that the more years of work is linked to an increase in perceived risk. Thus, the researchers formulated: Null hypothesis: $H_o = \mu \leq 5.5$, Alternate hypothesis: $H_1 = \mu > 5.5$

Table 9. Generated Data for One-sample T-test

t-test: One sample	***Data***
Mean	6.4091
Variance	4.8248
Observations	22
Hypothesized Mean	5.5
df	21
t Stat	1.9413
P (T≤ t) one-tail	0.0329
t Critical one-tail	1.7207

Based from the generated values using Minitab, shown in Table 9, the result of the t-test is 1.9413 having a one-tail p-value of 0.0329, and the one-tail *t* critical of 1.7207.

Table 10: One-sample T-test Summary

Summary of results for 1-sample t-test	
Hypotheses	H_o: $\mu \leq 5.5$ H_1: $\mu > 5.5$
Rejection Region	Reject H_o if $t > 1.7207$
Test Statistics	$t = 1.9413$
p-value	*p-value*: 0.0329
Decision/Conclusion	Because $t = 1.9413 > 1.7207$ ∴ **Reject H_o**

Table 10 shows that using one-tailed test, there is no difference between groups in specific direction. Thus, Reject H_o if *t* is equal to the *t Critical* value of 1.7207. In conclusion, the researchers rejected the H_o since the value of *t* is greater than the value of the *t Critical*.

Table 11. Data analysis in Mean, Median, and Mode

Analysis	**Formula**	**Result**

Mean	x= i=1nxin = x1+x2+…+xnn	6.4091
Median	x= 12(xn2+xn2+1)	7.0
Mode	Most frequent number	**7.0**

The computed values are 6.4091 for the sample mean, 7.0 for the median, lastly, 7.0 for the mode. From the results of all statistical analyses that was presented in Table 11, the researchers acknowledged that risk threshold must be derived from the generated values of the median and mode of 7.0. Likewise, the median was the middle value or "true center" of the data, as well as the mode with indicates the value that occur most frequently in the data.

5.2 Graphical Results

Table 12. DMRA Matrix for Inventory Management Processes

		Consequence→				
		1 (Insignificant)	2 (Minor)	3 (Moderate)	4 (Major)	5 (Very Significant)
Likelihood →	5 (Almost Certain)	5	10	15	20	25
	4 (Likely)	4	8	12	16	20
	3 (Possible)	3	6	9 **SH1, SH5**	12	15
	2 (Unlikely)	2	4	6 **SH2, SH4**	8	10
	1 (Rare)	1	2	3 **SH3**	4	5

The risk matrix illustrates the status of their inventory management processes. From the results and evaluation, as shown in Table 12, SH1 and SH5 fall in the Medium Risk category, and for Mitigation, risks SH2 and SH4 fall in the Medium Risk, and SH3 fall in Low Risk, all acceptable for Preventive Actions.

Table 13. Interpretation of Risk Matrix Evaluation

	Risks Description	**Risk Score (S x L)**	**Decision**
	Storing and handling process		
SH1	**Failure in segregation of hazardous chemicals according to their classification**	**9**	**Mitigate**
SH2	Hazardous chemicals not properly stored in their designated containment	6	Accept
SH3	Hazardous chemicals are stored in an inappropriate or unsafe storage and handling systems (racks, tanks, etc.) or equipment	3	Accept
SH4	Accidental leaks, spills, and release of hazardous chemicals during storage	6	Accept
SH5	**Failure to eliminate unnecessary, unused, or outdated hazardous chemicals from laboratories and chemical storage areas**	**9**	**Mitigate**
	On-site transportation process		
T1	Lack of warning labels in the hazardous chemicals during transport	3	Accept
T2	Failure to follow the separation and segregation rules for transporting mixed classes of hazardous chemicals	6	Accept

T3	Accidental leaks, spills, and release of hazardous chemicals during transport	6	Accept
	Ordering process		
O1	Failure to follow the Purchase Order Protocol for ordering of hazardous chemicals	3	Accept
O2	Wrong or excessive items was delivered due to placing of incorrect product information in the order sheet	6	Accept
O3	**Delay in delivery (from supplier) of hazardous chemical products**	**9**	**Mitigate**

Table 14. Significant factors that contribute to hazards and risks

Risk Factors		Wilcoxon Statistic	Estimated Median	p-value
Organizational factors	*P1*	48.0	3.5	0.093
	P2	58.5	4.0	0.204
	P7	39.0	3.5	0.023
Technical factors	*P3*	58.5	4.0	0.204
	P4	72.0	3.5	0.113
	P8	35.0	3.5	0.082
Human factors	*P5*	56.0	3.5	0.103
	P6	58.5	4.0	0.204
Condition: Test for median = 4.0 α = 0.05 (95% CL)		*Test:* Null hypothesis Alternative hypothesis		 H_o' $\eta = 4$ H_1' $\eta < 4$

The analysis is a non-parametric test and due to not being in normal distribution. To evaluate, as shown in Table 13 and Table 14, the researchers tested the probability of 4 as median, a value near the actual average computed median for the data, formulating the both null and alternative hypothesis, equal and less than 4, respectively. The significant value (p-value) of the Wilcoxon test is accepted if α = 0.05 (95% CL), is less than the p-value, otherwise, failure to reject Ho.

5.3 Proposed Improvements

The criteria formulated by the researchers will be used for the risk treatment plan according to the risk levels from the risk matrix. The figure is based on the Health, Safety, and Environmental Services (HAZCON) of Australia (2020). When the risk is at the low level, plan could be: use of protective equipment and reduce exposure to the hazard using administrative actions. When it is at the medium risk: reduce exposure to the hazard using administrative actions, reduce the risks through engineering controls, and isolation of hazards to people and substitution of hazard with something safer. Lastly, when at high risk, isolation of hazards to people and substitution of hazard with something safer, and elimination hazards can be used as a measure for the control. The graphical representation of the Hierarchy of control is shown in Figure 2.

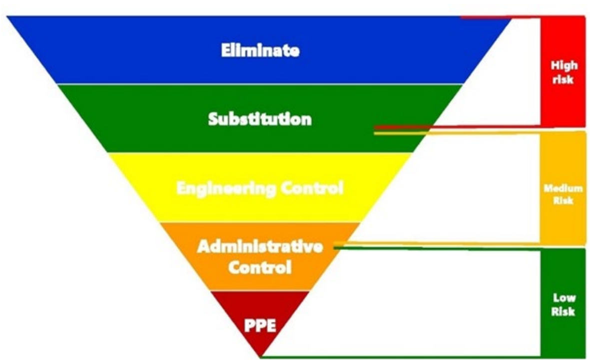


Figure 2. Hierarchy of Control for Risk Treatment Plan

Through the regulation of NIOSH's Hierarchy of Control, the researchers systematically strategized the control of exposure to hazards. Engineering controls are highlighted to the three different processes (Storing/Handling, On-Site

Transportation and Order Processing) to provide the appropriate measurements and actions that would reduce the likelihood of hazard events to the employees in the laboratory. The Control Plan can serve as a guideline and a Preventive Measure Plan to manage risks that may appear in the inventory management of the laboratories. Recommended sample of Risk Treatment Matrix is shown in Figure 3.

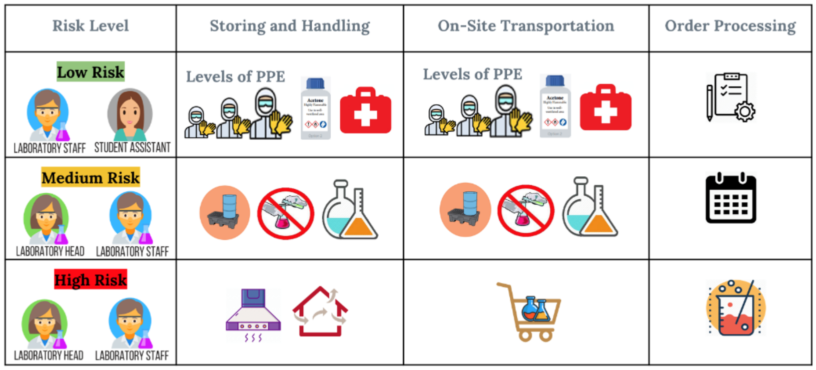


Figure 3. Establishment of Risk Treatment Matrix Plan for all Laboratories

6. Conclusion

Based from the results of the study, the researchers concluded that only one of the eight possible factors, P7 or "Using Standard procedures for any possible emergency/uncertainties" is found to be significant, and the remaining seven are not causal factor.

Through the utilization of HAZOP analysis, the guide words maximized the questioning part of the researchers in evaluating the possible errors and revealing the gaps of the management in the laboratories. The DMRA technique, on the other hand, determined three needed mitigation plans to focus on. With the derived risk threshold value of 7 that also served as the baseline in identifying the 3 out of 11 or 27% contributing factors, namely: (1) Failure in segregation of hazardous chemicals according to their classification, (2) Failure to eliminate unnecessary, unused, or outdated hazardous chemicals from laboratories and chemical storage areas, and Order Processing having (3) Delay in delivery (from suppliers) of hazardous chemical products. The three hazards obtained the highest risk score of 9 from the three different factors in accordance to inventory management of hazardous chemicals.

New policies and guidelines that could be implemented in the institution are follows: (1) Utilization of NIOSH's Hierarchy of Controls, (2) Development of Risk Treatment Plan for Hazardous Chemicals, and (3) Establishment of Chemical Exposure Risk Assessment. The researchers recommend the adaptation and application of the presented policies and procedures to align with OSHA, GHS and DOLE's statutory laws and regulations. Annual update of the Chemical Management Plan in all of the laboratories is recommended to align with statutory standards, as necessary. Moreover, establishment and development of documented data in terms of the accidents and hazards that the laboratories have encountered would help determine the likelihood of the hazard leading to a more controlled and managed exposure to hazards and risks. Lastly, future researchers could focus particularly in managing the exposure of the personnel (health status) working in the University laboratory to develop a specific mitigation and control plan of hazards associated with the intended respondents.

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