



Proposed Solutions to Vaccine Storing and Distribution at PT. POS Logistik Indonesia, Bandung

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ABSTRACTS

This case study digs into the involvement of students in the logistic engineering curriculum at Universitas Pendidikan Indonesia in real-world logistics problems. The research is based on a consulting project carried out in partnership with PT. POS Logistik Indonesia, is a well-known logistics company specializing in health and vaccine product warehousing. The primary responsibility allocated to the students is to meticulously observe, thoroughly analyze, and provide solutions for material handling procedures within the boundaries of the company's warehouse facilities. While the main goal was to collect visual documentation of the warehouse, PT. POS Logistik Indonesia delivered Standard Operating Procedure (SOP) documents relevant to health and vaccine product management. This made it possible to approach the consultation assignment in a more collaborative and informed manner. The primary goal of this article is to identify relevant difficulties and formulate prescriptive solutions based on interviews and on-site visits, with a particular emphasis on the improvement of vaccine storage and handling techniques to avoid waste in future initiatives.

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1. INTRODUCTION

Case study is an essential part of studying and analyzing on-site cases instead of the office (Antti Oulasvirta et al, 2003; Bazeley P., 2015; Rashid, Y.,2019). Universitas Pendidikan Indonesia conforms to this practice, particularly the logistic engineering study program, which provides an opportunity for students to engage in real logistic scenarios in the industry through a program called project consultation. In this case, the project consultation connects the 7th group from class A of the 2021st batch with PT. POS Logistik Indonesia. PT. POS Logistik Indonesia is a well-known logistic company that currently specializes in regular and cold storage for health and vaccine products. The company is in Bizpark, Jl. Raya Kopo No.455, Cibirangrang, Kec. Babakan Ciparay, Kota Bandung, Jawa Barat.

PT. POS Logistik Indonesia provides service coverage for the storage and distribution of vaccines across West Java. The company acts as the intermediary, providing logistic aid for the health ministry to health facilities in their area. Following the purpose of the project consultation, students are expected to observe – analyze – and propose solutions concerning their findings. It is noted that during the project consultation visit, photo or video documentation related to the warehouse is to be taken and reported publicly. However, PT. POS Logistik Indonesia was able to provide documents related to the SOP of health and vaccine product handling. Thus, a better constructive approach to the consultation project was able to be upheld.

The purpose of this paper is to identify issues and propose solutions to the logistics activity, specifically material handling, throughout several interviews and visits. The report is presented to encapsulate the comprehensive outcomes of the observational study, problem identification, observational analysis, and practical solutions. The document is anticipated to effectively articulate the findings of the investigations, along with pertinent record documents, to aid readers in enhancing the efficiency of vaccine waste storage and handling procedures in the future.

2. METHODS

This article employs a variety of qualitative methodologies to identify, analyze, and propose solutions to problems identified during interviews and observations at PT. POS Logistik Indonesia. The first stage is to identify real-world problems based on interviews with three workers: distribution supervisors, distribution operators, and warehouse operators. This identifying method is aided further by observational findings. Following that, validated interview assertions supported by strong physical evidence are subjected to fishbone analysis to categorize variables for further discussion. The following phase comprises doing root cause analysis on the selected variables to identify critical company issues and associated causative variables. These results serve as guidelines for this article. The third step comprises developing viable solutions based on the essential factors identified through root cause and fishbone analysis.

The Hazard and Operability Study (HAZOPS) is used in this paper to address risk identification, regulatory compliance, and safety enhancement. Furthermore, this step includes a rigorous literature assessment to strengthen theoretical foundations and support the offered solutions. It is critical to include scholarly results as documents. The search results were restricted by using inclusive and exclusive criteria and collecting data from international publications and health ministries. To find relevant web reports and papers, use keywords like "Cold chain," "Vaccine handling," "Vaccine quality control and assurance," "Vaccine distribution," "Zero-waste vaccines," "Vaccine stock evaluation," and "Vaccine workers" in database searches.

3. RESULTS AND DISCUSSION

3.1 Interview

The interview was done twice with three workers using top-down approach based on their work responsibility in the company. The workers in question are the representation from distribution supervisors, distribution operators, and warehouse operators. The questions used in the interview are the same for each representative. The questions are divided into three parts: warehouse, distribution, and Quality Control (QC). However, each worker highlights different parts of the question differently according to their job scope. The highlights are as follows: distribution supervisor for distribution overview process, distribution operator for an in-depth distribution process and QC, and warehouse operator for warehouse processes and QC. The questions are detailed more in [Table 1].

Table 1. Interview Questions for The Worker Representation of PT. POS Logistik Indonesia

	<i>Distribution</i>	<i>Warehouse</i>	<i>QC</i>
1	What modes of transportation are used by the company? Are there any special (unique) modes (unique) modes used for the distribution process?	How big is the warehousing area of PT POS Logistik and what facilities are available there?	Is there any standardization to maintain the quality of operations at PT POS Logistik?
2	Does the company conduct planning (route, number of modes, delivery time) before distribution?	What goods does PT POS Logistik receive in its warehouses?	Does PT POS Logistics implement stock audit?
3	What areas does the company reach and which areas are most frequently visited? Why?	What is the method/process of storing products in the warehouse?	Does PT POS Logistik use public audit services to assess company performance?
4	Are there any problems other than the issues that have been raised by customers on PT POS Logistik's delivery process?	Does PT POS Logistik set a special standard (uniqueness) for the material control process?	
5		How is the administration system for storing and issuing goods?	
6		Are there any storage and management issues in the warehouse?	

Recording of the interviews was conducted for all participants except for the representatives of distribution warehouse workers. Although each representative covered a different part of the interview subject, only some of the questions were answered. Time constraints tied to the worker's job schedule made the interview partially effective. Fortunately, there are several key points taken from the interviews. First, the interview was able to provide the scope of responsibilities and capabilities of PT. POS Logistik Indonesia handle. Second, it has been expressed multiple times that there are issues regarding the storing and distributing of vaccines in the year 2020-2021 year. Third, each representative has different versions of detail for the same issue. The interview result is depicted shortly in [Table 2].

Table 2. Summarized Interview Answers with PT. POS Logistik Indonesia's Representative

<i>Distribution Supervisor</i>	<i>Distribution Operator</i>	<i>Warehouse Worker</i>
D1: The company uses several CDD trucks that can store vaccine in cold temperature	D1: The company uses several CDD trucks that can store vaccine in cold temperature	W1: There are three cooled containers, one UCC, two ice-pack fridges, several pallet truck, and temperature monitoring systems
D2: The company moves based on the formal instruction from the health ministry of when and where to distribute and store vaccines	D4: There are several cases where some vaccine vials were broken upon receipt in the warehouse.	W2: Vaccines, masks, syringes, etc
D3: West Java, particularly health facilities near the branch	D4: Vaccines are also quite unpopular for the masses, making a surplus in vaccine that adds to expired goods in the warehouse	W3: The process is divided into four: inbound, audit, monitor, and outbound
	D4: Occasionally the inbound goods quantity is not aligned with the quantity stated in the inbound administration documents	W5: There were a case where a vaccine vial was broken upon receipt in the warehouse. Although the company was not held responsible for it since it was them who distribute it initially
	W1: The warehouse store vaccine vials in either a cooled 20 ft container or Ultra Cold Chain (UCC)	QC2: In every shipment, an audit personnel are always present to ensure the quality and quantity of the deposited vaccine

It can be inferred from the interview that PT. POS Logistik Indonesia handles both medical equipment and vaccine vials in their warehouse. The company has a wide reach of distribution channels to health facilities as per the instruction of the Ministry of Health. It was explained by the distribution supervisor that the shipping of vaccine vials is done only when the Ministry of Health of Indonesia posted a shipping statement to the company including the time, place, and quantity of goods (Pambudi, N. A., Sarifudin, A., Gandidi, I. M., & Romadhon, R, 2022). The warehouse in question has significant storage capacity, allowing for effective cooling of products to temperatures as low as -2°C (through chilled containers) or even -40°C (via Ultra-Cold Chain, UCC). PT. POS Logistik Indonesia has also installed a temperature monitoring system to maintain an appropriate warehouse environment.

Obstacles emerged for the past 2 years, mainly in the area of vaccine distribution, over which the company has no direct influence. The inbound supply of vaccinations is beset by quality and quantity assurance difficulties (Ganczak M., Gil K., Korzeń M., Bazydło M, 2017; Garabadu S., Panda M., Ranjan S., Nanda S. , 2020) which ultimately fall into the hands of the suppliers (Ghoghaei others M.S., 2020; Haidari others L.A., 2013; Hasanat R.T., Mansoor N., Mohammed N., Rahman M.S., Rasheduzzaman M., 2023; Hatchett R., 2017). This situation is exacerbated by a persistent lack of demand for vaccines, along with an excessive oversupply, increasing vaccine expirations. This scenario not only puts pressure on the warehouse because of the surplus of vaccine vials, resulting in higher operational expenses, but it also creates possible chemical dangers for personnel.

3.2 Observation

The vaccine storage warehouse observation was conducted as a follow-up step to understand and evaluate the crucial vaccine storage conditions. The observation was also an opportunity to confirm the issues raised in the previous interview sessions. The main purpose of this observation was to ensure that the vaccines are maintained with proper storage standards so that their quality and effectiveness are maintained before distribution. PT POS Logistik Indonesia is known to perform distribution and storage services for medical devices and vaccines. The warehouse is divided into two that are attached, except that the warehouse

for medical devices is open while the vaccine warehouse is closed. Warehouses with different characteristics also have different visit handling, where the vaccine warehouse has an entrance that can only be opened using an employee card to maintain the storage room environment. On the other hand, the medical equipment warehouse can be visited directly because the warehouse door is always open with a much higher flow of employee movement.

This observation was aimed only at analyzing the facilities, processes, and issues in the vaccine warehouse because no issues have been found so far with the storage of medical devices. The warehouse is equipped with various facilities to provide optimal storage conditions for vaccinations. Key features include three 20-foot refrigerated containers capable of maintaining temperatures as low as 2-8°C and one Ultra-Cold Chain (UCC) unit capable of maintaining temperatures as low as -40°C. The refrigerated containers have a maximum total capacity of 1 million vials, while the UCC is 3120 vials. All types of vaccines are stored in refrigerated containers except Pfizer-type vaccines. This is because Pfizer has special characteristics that only have optimal effects in frozen conditions at temperatures around -40°C. Therefore, the warehouse is only able to hold a much smaller amount of Pfizer vaccines than other types of vaccines. Even so, the vaccines in the hands of PT POS Logistik Indonesia are stored in a neat and coordinated order.



Figure 1. Illustration of the CDD Truck (Left) and UCC (Right) Facility Used by PT. POS Logistik Indonesia, Bandung

The observation team also had the opportunity to see vaccine storage in the form of container boxes. The temperature inside this storage must be maintained by an employee every hour and recorded on a blackboard. When the vaccines have passed the validity period, they will be taken from storage and collected in one container. Once collected in large enough quantities, the vaccines will be handed over to the Ministry of Health for destruction. Inside this warehouse, the observation team was not allowed to take photos due to the vital importance of the object. Finally, the team decided to take pictures outside the warehouse with the workers.

In addition, the warehouse has additional equipment such as pallet trucks and ice pack refrigerators easily available to meet operational needs. The pallet truck is essential to enable the direct transfer of incoming vaccinations from the transport truck to the cold storage room. This procedure is required by the vaccination audit protocol, which requires maintaining ideal temperature stability within the cold storage compartment. On the other hand, the ice pack refrigerator serves as an additional facility designed to prepare ice packs that will be inserted into vaccine containers during transit. This strategic move arises from the realization that vaccine temperatures have the potential to fluctuate during the transition period between storage locations and during the distribution process. The ice packs serve as temperature stabilizers, thereby mitigating the conditions. The entire infrastructure of the facility is also supported by temperature control and monitoring equipment, such as temperature sensors and panel display. This temperature monitoring system helps the company closely monitor

the fluctuations that occur throughout the day in the vaccine storage temperature.

3.3 Analysis

Fishbone analysis is used to aid root cause analysis by identifying critical factors inside the vaccine warehouse operation (Abdulaziz AlQahtani et al., 2020). [Figure 1] depicts the identification of six major components and their associated variables. Notably, except for transportation and environmental considerations, all major variables have a higher hierarchy in connection to growing warehouse issues in Figure 2.

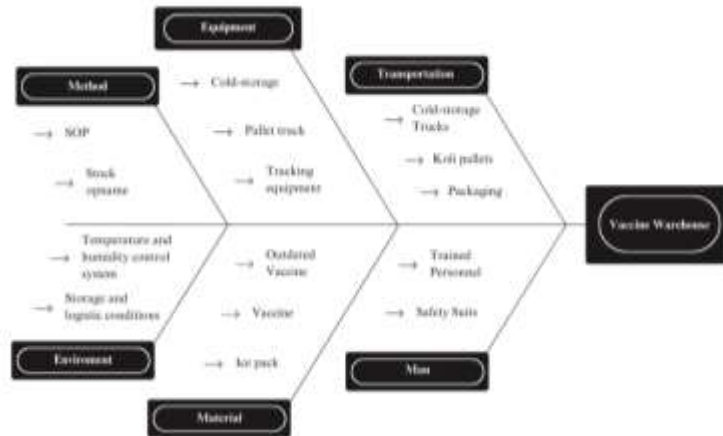


Figure 2. Analysis of Fish Bone Vaccine Warehouse

The research uncovers considerable difficulties in labor, materials, and vaccination handling and storage operations. Workers may lack necessary understanding for proper vaccine management despite two years of training. Effective training, greater communication, and stricter enforcement of safety regulations are required (Clarke, 2012). In terms of materials, the existence of obsolete vaccinations could jeopardize efficacy and safety. Improving inventory management and disposing or recycling of obsolete vaccinations provides an opportunity for waste reduction and resource efficiency. Furthermore, despite existing standard operating procedures, shortcomings in quality assurance and control suggest that these processes should be thoroughly reviewed and updated.

The preceding fishbone study highlighted potential causes of unsatisfactory storage and quality. Following the identification, the investigation is carried out utilizing root cause analysis to look deeper into critical components that may be linked to vaccine-related concerns. As shown in [Figure 2], "Method," "Material," "Man," and "Equipment" emerged as crucial variables significantly influencing quality optimization in Figure 3.

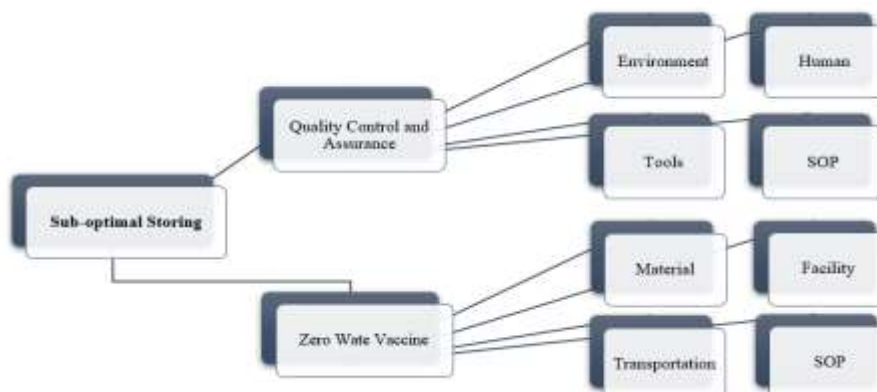


Figure 3. Root cause analysis of sub-optimal storing caused by 4 main factors and 2 side factors warehousing

Subsequently, the reduction in storage quality is caused by a few reasons, the most significant of which are Quality Control and Assurance (QCA) and the accumulation of old vaccines, each of which has a specific impact. Apart from appropriate environmental controls, QCA implementation at PT. POS Logistik is unsatisfactory. SOPs interact with safety compliance, although both people and equipment aspects may not fully adhere to SOPs, necessitating restructuring.

The presence of various obsolete vaccination brands raises issues regarding the effectiveness of storage management. Due to the lack of apparent expiration dates, identifying old vaccinations can be difficult, potentially leading to misidentification and contamination hazards. Furthermore, storing outmoded vaccines outside the cold chain exposes them to temperature fluctuations and environmental factors, jeopardizing their efficacy. Expired vaccinations must be recycled properly, and the company now transfers them to a recycling facility in Jakarta. Investigating zero-waste vaccine methods and preventing overstocking while conducting frequent stock inspections can considerably reduce the dangers associated with outdated vaccine storage and improve overall system efficacy.

3.4 Solutions

3.4.1 Hazard and Operability Study

The Hazard and Operability Study (HAZOPS) method, which is based on root cause analysis of "Method," "Material," and "Man," is a critical tool for PT Pos Logistik in identifying and managing operational risks. This method entails a thorough assessment of work methods (Method), material types and quality (Material), and the function of individuals (Man) in operational operations. It goes beyond treating symptoms to determining the fundamental causes of potential problems, allowing PT Pos Logistics to take exact action to reduce operational risks and improve safety and security.

While risk analysis is generally related to insurance and investments, it also has applications in workplace analysis and hazard mitigation. According to Goetsch (2007), risk analysis seeks to assess the magnitude of risks by considering their likelihood and potential effects. It entails predicting the chance of an event as well as the magnitude of its impact on safety, health, the environment, and finances within a given timeframe. The Hazard Operability Study (HAZOPS) technique emerges as the most appropriate analytical tool in the quest for operational safety and security at PT Pos Logistics.

The HAZOPS method was selected because of its systematic and comprehensive approach to detecting potential hazards and problems that may develop during operational procedures. It provides systematic and integrated insights into numerous operational aspects such as product movement, storage, transportation, and distribution. Given the complexities of PT Pos Logistik's activities, HAZOPS excels at identifying possible hazards, especially those that are not immediately obvious. Additionally, it gives profound insights into risk avoidance and mitigation by an intensive study of complicated operational interconnections, eventually ensuring safe, efficient, and controlled operations.

Following a systematic procedure modified from Alfatiyah et al. (2017) and Restuputri & Sari (2015), the team's technique includes identifying probable failures or high-risk scenarios that could affect corporate safety and security: identification of work/activity, description of job/activity, identification of potential hazard findings, assessment of hazard impact, and conducting a comprehensive risk assessment in Table 3.

Table 3. Results of HAZOPS for PT Pos Logistik
(Risk Assessment *Tingkat risiko = Likelihood x Exposure x Consequence*)

Division	Activities	Description of Potential Hazards	Risk Impact	Risk Assessment			Risk Level
				L	C	S	
Staff Manager	Use of Vaccine Storage Aids	Use of UCC and Cold Storage that is not in accordance with procedures causes damage to vaccines	Vaccine temperature maintenance cannot be implemented properly	3	2	6	Medium
Engineering	Maintenance of Air Conditioners such as UCC and Cold Storage	Damage to equipment that causes the vaccine temperature to not be maintained	Vaccines will spoil, expire, unfit for use, and contaminate the environment	4	3	12	High
	Use of tools such as RFID, insulation pad, etc.	Vaccine maintenance is not running smoothly	Vaccines will spoil, expire, unfit for use, and contaminate the environment	4	2	8	High
	Maintenance of tools in the warehouse	Temperature control cannot run smoothly due to broken equipment	Vaccine temperature maintenance cannot be implemented properly	3	2	6	Medium
Security	Safeguarding Vaccines from threats that can damage them	Vaccine damage due to accidental damage (non-employees) and not knowing the Warehouse SOP correctly	Vaccine temperature maintenance cannot be implemented properly	3	1	3	Low

The HAZOPS technique will be used in the risk identification process, which will include a review of existing literature, direct observations, and interviews with Occupational Safety and Health (OHS) specialists (Anita Trisiana et al, 2019). Potential dangers that could lead to occupational accidents will be identified through a review of the literature, direct observation, and expert interactions. Following identification, the HAZOPZ team will undertake a full risk evaluation, assessing severity, probability, and overall risk level using the company's set criteria. Following that, recommendations for corrective actions or risk controls to address the identified possible risks will be developed in Table 4.

Table 4. Corrective action or risk control that needs to be done for PT POS LOGISTICS

Division	Potential Hazards	Causes of Harm	Proposed Improvements
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Staff Manager	Use of tools that do not comply with SOPs and can harm the company	Employees who do not understand SOPs properly and Human Error	
Engineering	Misuse of vaccine aids that results in vaccine damage	Workers who do not carry out OHS, SOPs, and provisions needed in carrying out machine operations	Provide OHS training and deepen knowledge of SOPs in the warehouse
Security	Make people who do not know the provisions in the Warehouse tamper with the vaccine	Security negligence in guarding Warehouse entered by inexperienced people	

The resolution of the HAZOP variables used in PT Pos Logistik includes various steps to reduce risk and ensure the sustainability of the company's operations. Some of the solutions that can be implemented are:

1. Security and Surveillance System Design: PT Pos Logistik can implement advanced security measures, including CCTV, fire alarms, and stringent access controls, to safeguard the workplace against potential threats.
2. Employee Training and Awareness: Regular training programs can be instituted to educate employees on safety protocols and emergency procedures, fostering heightened awareness of risks and the imperative of adherence to safety guidelines.
3. Comprehensive Emergency Planning: Developing an all-encompassing emergency plan to address natural disasters, accidents, and crisis scenarios is critical. This plan should entail organized evacuation procedures, provision for first aid, and effective communication strategies.
4. Routine Maintenance and Inspections: Regular inspections and maintenance checks of equipment, vehicles, and infrastructure are essential to ensure optimal functionality and alignment with established safety standards.

The results of the analysis that has been carried out through the HAZOPS method have inspired important decisions to improve operational management and security at the warehouse. This decision is related to the separation into two different Standard Operating Procedures (SOPs), namely "External Visit Handling" and "Vaccine Storage Control". This decision is not only the result of finding potential hazards in the operational process, but also based on important aspects identified through HAZOPS analysis.

3.4.2 Standard Operating Procedure

The "Handling of External Visits" Standard Operating Procedure (SOP) has two important main objectives. First, this SOP aims to ensure the safety and security of company facilities by organizing external visits. It helps reduce security risks by identifying parties who are allowed to access certain areas and protecting confidential company information. Second, this SOP serves as a clear guide in organizing and supervising external visit activities, including determining the purpose of the visit and scheduling it in a structured manner. As such, the "External Visit Handling" SOP is critical in maintaining the integrity of the company's operations and protecting valuable information. On the other hand, the SOP "Vaccine Storage Control" was created in response to findings related to vaccine storage. This document will describe the steps to be taken to closely monitor storage temperatures, manage vaccines approaching their expiration date, and identify actions to be taken in the event of spoiled or expired vaccines



Figure 4. Correspondent Monitoring Document Attached in the SOPs

3.4.3 Review Document

From the analysis of existing HAZOPS and SOPs, it was found that the review document has a very important role as the main solution for this company. The assessment document plays a central role in maintaining vaccine quality and safety. With a detailed and structured assessment document, the company can carefully plan, manage, and supervise all stages in the vaccine distribution chain, ensuring strict control by strict safety guidelines. Therefore, the study document is not just a guide, but also a very important tool in maintaining the quality and safety of vaccine products, which is a central element in PT POS LOGISTIK's mission to support public health.

It is important to clarify that an in-depth review of PT POS LOGISTIK's data and procedures is not only a regulatory obligation but also a valuable investment in improving the company's overall quality. By relying on a robust review document, the company can more effectively identify areas for improvement, implement timely improvements, and minimize the risk of operational failures. This in turn will improve the quality of services provided to customers, strengthen the company's image, and increase public confidence in the vaccine products processed and distributed by PT POS LOGISTIK. As such, review documents play an important role in helping companies achieve higher quality standards and maintain a strong reputation in the market.

4. CONCLUSION

The HAZOP risk assessment method is highly effective in identifying and evaluating potential hazards and risks within PT Pos Logistics' vaccine warehouse operations, emphasizing the importance of clear and comprehensive Standard Operating Procedures (SOPs) in minimizing errors and ensuring safety. The importance of occupational safety and health (OHS) in this analysis cannot be overstated, as it prioritizes employee safety, accident prevention, and good working environments. Regular employee training for procedural comprehension, continued equipment, and infrastructure monitoring, increased OHS awareness, provision of suitable personal protective equipment, and policy implementation to incentivize OHS compliance are among the proposed enhancements. Finally, HAZOP enables PT Pos Logistics to identify and handle vaccine storage hazards, thereby raising safety standards, protecting the workforce, and assuring uninterrupted logistics operations, particularly in the vital arena of vaccine management for public health.

5. REFERENCES

- Alfatiyah, R. (2017). Analisis manajemen risiko keselamatan dan kesehatan kerja dengan menggunakan metode HIRARC pada pekerjaan seksi casting. *SINTEK JURNAL: Jurnal Ilmiah Teknik Mesin*, 11(2), 88-101
- AlQahtani, A., London, N. R., Castelnuovo, P., Locatelli, D., Stamm, A., Cohen-Gadol, A. A., ... & Carrau, R. L. (2020). Assessment of factors associated with internal carotid injury in expanded endoscopic endonasal skull base surgery. *JAMA Otolaryngology–Head & Neck Surgery*, 146(4), 364-372.
- Bastuti, S. (2021). Analisis Tingkat Risiko Bahaya K3 pada Pengelolaan Apartemen Menggunakan Metode Hazard Operability Study (HAZOPS). *Jurnal INTECH Teknik Industri Universitas Serang Raya*, 7(1), 7-14.
- Bazeley P. (2015). Mixed methods in management research: Implications for the field. *Electronic Journal of Business Research Methods*, 13, 27–35.
- Clarke, S. (2013). Safety leadership: A meta-analytic review of transformational and transactional leadership styles as antecedents of safety behaviours. *Journal of occupational and organizational psychology*, 86(1), 22-49.
- Ganczak M., Gil K., Korzeń M., Bazydło M (2017). Coverage and influencing determinants of

- influenza vaccination in elderly patients in a country with a poor vaccination implementation. *Int. J. Environ. Res. Publ. Heal.*;14(6):665. doi: 10.3390/IJERPH14060665.
- Garabadu S., Panda M., Ranjan S., Nanda S. (2020). Assessment of vaccine storage practices in 2 districts of eastern India -Using global assessment tool. *Int. J. Heal. Clin. Res.* ;3(11):62–66.
- Ghoghaei others M.S. A review on the applications of micro-/nano-encapsulated phase change material slurry in heat transfer and thermal storage systems. *J. Therm. Anal. Calorim.* 2020;145(2):245–268. doi: 10.1007/S10973-020-09697-6.
- Haidari others L.A. Augmenting transport versus increasing cold storage to improve vaccine supply chains. *PLoS One.* 2013;8(5):1–7. doi: 10.1371/journal.pone.0064303.
- Hasanat R.T., Mansoor N., Mohammed N., Rahman M.S., Rasheduzzaman M. Development of a monitoring system and power management for an IoT based vaccine carrier. *J. Phys. Conf. Ser.* 2021;1755(1) doi: 10.1088/1742-6596/1755/1/012023
- Hatchett R. The medicines refrigerator and the importance of the cold chain in the safe storage of medicines. *Nurs. Stand.* 2017;32(6):53–63. doi: 10.7748/ns.2017.e10960
- Geotisch, et. Al. 1996. *Safety and Health Management*. Amsterdam Hall: Mac Gill Inc
- Irfan, M., & Susilowati, I. H. (2021). Analisa Manajemen Risiko K3 Dalam Industri Manufaktur Di Indonesia: Literature Review. *PREPOTIF: Jurnal Kesehatan Masyarakat*, 5(1), 335-343.
- Oulasvirta, A., Kurvinen, E., & Kankainen, T. (2003). Understanding contexts by being there: case studies in bodystorming. *Personal and ubiquitous computing*, 7, 125-134.
- Pambudi, N. A., Sarifudin, A., Gandidi, I. M., & Romadhon, R. (2022). Vaccine cold chain management and cold storage technology to address the challenges of vaccination programs. *Energy Reports*, 8, 955-972. <https://doi.org/10.1016/j.egy.2021.12.039>
- Ramli, Soehatman. 2010. *Sistem Manajemen Keselamatan dan Kesehatan Kerja*. Dian Rakyat. Jakarta.
- Rashid, Y., Rashid, A., Warraich, M. A., Sabir, S. S., & Waseem, A. (2019). Case Study Method: A Step-by-Step Guide for Business Researchers. *International Journal of Qualitative Methods*. <https://doi.org/10.1177/1609406919862424>
- Restuputri, D. P., & Sari, R. P. D. (2015). Analisis kecelakaan kerja dengan menggunakan metode Hazard and Operability Study (HAZOP). *Jurnal Ilmiah Teknik Industri*, 14(1), 24-35.
- Rusnack, M. (2021). COVID Vaccine transport, storage, and distribution: cold chain management to ensure efficacy. *INNOVATIONS in pharmacy*, 12(4).
- Trisiana, A., Yafi, D. S. A., & Ratnaningsih, A. (2019). Assessment Risiko Kesehatan dan Keselamatan Kerja (K3) Menurut Variabel OHSAS Dengan Menggunakan Metode HIRA, HAZID dan HAZOP (Studi Kasus: Proyek Pembangunan Ciputra World Phase 3, Surabaya).