

RISK ASSESSMENT OF GOODS SORTING ACTIVITIES IN COLD STORAGE USING JOB SAFETY ANALYSIS (CASE STUDY: LOGISTICS WAREHOUSE, JAPAN)

Yelita Anggiane Iskandar^{1*}, Bathara Hananta Ramdhan¹, Lana Salsabila Muhyi¹, Rahma Alia Azzahro¹,
and Winda Septiana¹

¹Study Program of Logistics Engineering, Faculty of Industrial Engineering, Universitas Pertamina

Abstract

Goods sorting (shiwake) activities at the Shimohana Logistics warehouse in Atsugi, Japan, constitute the focus of this study, which aims to identify potential hazards, assess risk levels, and evaluate the implementation of occupational health, safety, security, and environmental (HSSE) practices. A qualitative descriptive approach was employed through direct observations, interviews, and documentation review, with risk analysis conducted using the Job Safety Analysis (JSA) method and risk assessment based on likelihood and severity parameters aggregated using the geometric mean. The results identified 11 potential hazards encompassing mechanical, ergonomic, and environmental aspects, with risk levels ranging from low to extreme. The highest risk ($RR = 16$) was associated with forklift traffic interactions in the sorting area, while other high risks ($RR = 9-12$) were linked to non-ergonomic postures, repetitive manual handling, and prolonged exposure to cold temperatures. Moderate and low risks were found in manual trolley usage, unstable stacking conditions, and exposure to scanner lighting. The application of JSA integrated with HSSE principles enables a structured and systematic approach to hazard identification and risk control. The findings indicate that, despite efficient warehouse operations, significant risks remain in sorting activities, particularly in worker–equipment interactions and cold environment exposure. Therefore, targeted mitigation strategies, including segregation of forklift and pedestrian pathways, ergonomic improvements, workload regulation, and the use of cold-resistant personal protective equipment, are recommended. These measures are expected to enhance workplace safety, reduce accident risks, and support continuous improvement toward a safer and more sustainable warehouse operation aligned with the zero-accident principle.

This is an open access article under the [CC BY-NC](#) license



Keywords:

Job Safety Analysis, Goods Sorting, Occupational Safety, Risk Assessment, Warehouse Operations

Article History:

Received: May 2nd, 2022

Revised: May 29th, 2022

Accepted: June 1st, 2022

Published: June 3rd, 2022

Corresponding Author:

Yelita Anggiane Iskandar
Study Program of Logistics
Engineering, Universitas Pertamina,
Indonesia

Email:

yelita.ai@universitaspertamina.ac.id

1. Introduction

In an increasingly integrated era of globalization, the logistics sector plays a vital role in supporting the stability of various industries, ranging from trade to manufacturing. Logistics functions as a strategic link between producers and consumers, ensuring that goods are distributed efficiently, delivered on time, and maintained in optimal condition [1]. In developed countries such as Japan, logistics systems have advanced significantly through

the adoption of high technology and stringent operational standards, particularly in cold chain logistics, where consumer demands for food freshness place cold chain management in a highly critical position.

The observed warehouse facility is one of the leading logistics companies in Japan, specializing in third-party logistics (3PL) services with a focus on handling temperature-sensitive food products. The company is supported by advanced cold storage infrastructure to maintain product quality throughout the distribution process and implements high standards of operational efficiency. Key operational activities in cold storage warehouses include inventory management processes such as goods receiving, strict quality inspection, and storage arrangement based on product categories to optimize space utilization and accessibility. In addition, the use of technologies such as handheld terminals and Warehouse Management Systems (WMS) plays a crucial role in improving accuracy and minimizing operational errors.

According to previous studies, forklift-related accidents represent a significant source of occupational injuries and fatalities in warehouse and industrial environments, particularly due to collisions, overturns, and struck-by incidents [2]. Furthermore, warehouse operations are characterized by a high prevalence of slips, trips, and falls, which account for a substantial proportion of non-fatal workplace injuries and are often associated with surface conditions such as wet or uneven floors [3]. In addition, cold storage environments present higher injury rates compared to general industry due to the combined effects of extreme temperatures, condensation hazards, and intensive equipment interaction, emphasizing the need for systematic hazard identification and risk control within operational settings [4,5]. Furthermore, daily risks such as slips, trips, falls, and exposure to extreme working conditions highlight the importance of systematic hazard identification and risk control within operational environments [6–8].

The goods sorting activity (*shiwake*, in Japanese) at a warehouse facility in Atsugi, Kanagawa Prefecture, represents a critical process within the distribution network of a Japanese discount supermarket chain, which operates multiple retail outlets and provides daily consumer goods, particularly food products, at competitive prices. As a retail company serving end customers directly rather than functioning as a wholesaler or distributor, this sorting process plays a vital role in ensuring the accuracy of quantity, product type, and delivery destination before shipment. Errors or disruptions at this stage can affect not only the quality of logistics services but also the occupational health and safety of operational workers [9]. Based on observations conducted during the internship period in the cold storage area, the *shiwake* process is performed in low-temperature environments ranging from below 0°C to 5°C, combined with a high level of physical activity. Workers perform manual sorting tasks across multiple work batches, involving lifting (Figure 1 (a)), bending and arranging (b), and transporting (c) frozen and chilled food products over relatively long periods. These conditions create significant occupational health and safety risks, particularly related to physical fatigue, reduced concentration, and musculoskeletal disorders caused by repetitive manual material handling [10].



Figure 1. Goods Sorting Activities

In addition to temperature and physical workload factors, risks also arise from the working environment. Cold storage areas typically have damp and slippery floors, increasing the likelihood of slip-and-fall accidents. Furthermore, the operation of material handling equipment, such as forklifts and hand pallets, within the same

workspace as workers introduces additional hazards, including collisions and near-miss incidents [11]. The combination of human factors, working environment conditions, and equipment usage makes the *shiwake* activity a high-risk operational process that requires particular attention. To provide a more comprehensive understanding of the complexity of these issues, the relationships among root causes, key phenomena, and resulting impacts in *shiwake* activities within the cold storage area can be visualized through a problem relationship analysis, as illustrated in Figure 2.

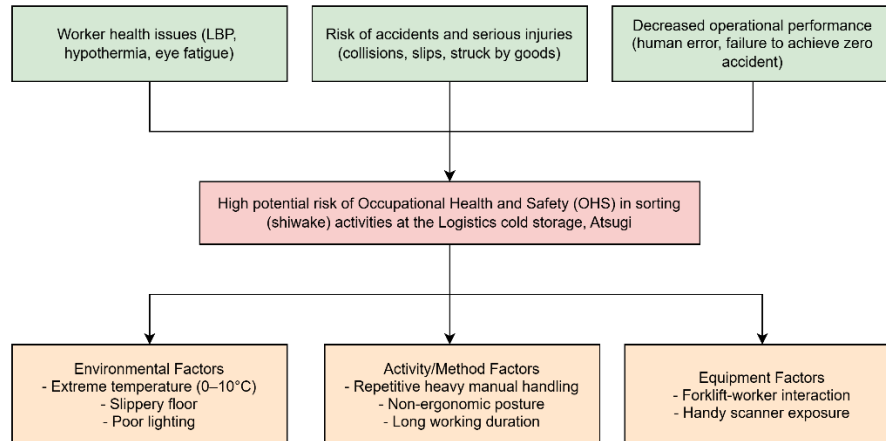


Figure 2. Problem Relationship Diagram

Although this logistics facility has implemented efficient operational systems and advanced warehouse technologies, the high productivity demands in cold storage areas may lead to insufficiently detailed identification of occupational safety aspects at each stage of activity. Without systematic hazard identification and risk control, the likelihood of workplace accidents and occupational diseases may increase, ultimately affecting operational performance, worker well-being, and the overall sustainability of the company's operations.

In addition to the risk factors illustrated in the problem tree, the physical conditions and operational layout of the warehouse in Atsugi also influence the level of occupational safety. Based on the warehouse layout, limited space leads to close interaction between manual workers and the traffic routes of heavy equipment, such as forklifts. The proximity of work areas to internal transportation routes, combined with damp and slippery floor conditions, creates high-risk points that may lead to accidents and disrupt the smooth flow of food logistics distribution. Therefore, a structured occupational safety analysis approach is required to identify potential hazards at each stage of the *shiwake* process. The Job Safety Analysis (JSA) method is considered appropriate, as it enables detailed mapping of work activities, identification of potential hazards, and formulation of effective risk control measures. This analysis is expected to serve as a basis for improving occupational health and safety, particularly in goods sorting activities within this cold storage facility, to support the creation of a safe working environment aligned with the principle of zero accidents [12]. Based on this background, the research questions of this study are as follows:

1. What potential hazards are present at each stage of the sorting (*shiwake*) process in the observed logistics cold storage warehouse?
2. What are the risk levels associated with each of these hazards in relation to worker safety and health?
3. What risk control measures can be proposed using the Job Safety Analysis (JSA) method to minimize workplace accidents and occupational diseases in the *shiwake* area?

2. Method

This study aimed at identifying, analyzing, and evaluating occupational health and safety (HSSE) risks in operational activities within the warehouse under study. The research method employed is Job Safety Analysis (JSA), which breaks down work processes into specific tasks to identify potential hazards, assess risk levels, and determine appropriate control measures to minimize the likelihood of workplace accidents. The object of this study is the goods sorting activity within the warehouse, which consists of several stages, including item picking, checking the quantity and condition of goods, transferring items from pallets to handling equipment, and placing goods into storage or dispatch areas. The subjects of the study are the workers involved in these sorting activities.

Figure 3 illustrates the research flow and scope, which includes the stages of observing the sorting activities, problem identification, literature review, field data collection, data processing using the Job Safety Analysis (JSA) method, results analysis, and conclusion drawing. The study begins with an observation of the research object to understand the conditions and context of the study area and to gather primary information. This is followed by problem identification based on observations, interviews with key informants, and a review of relevant literature.

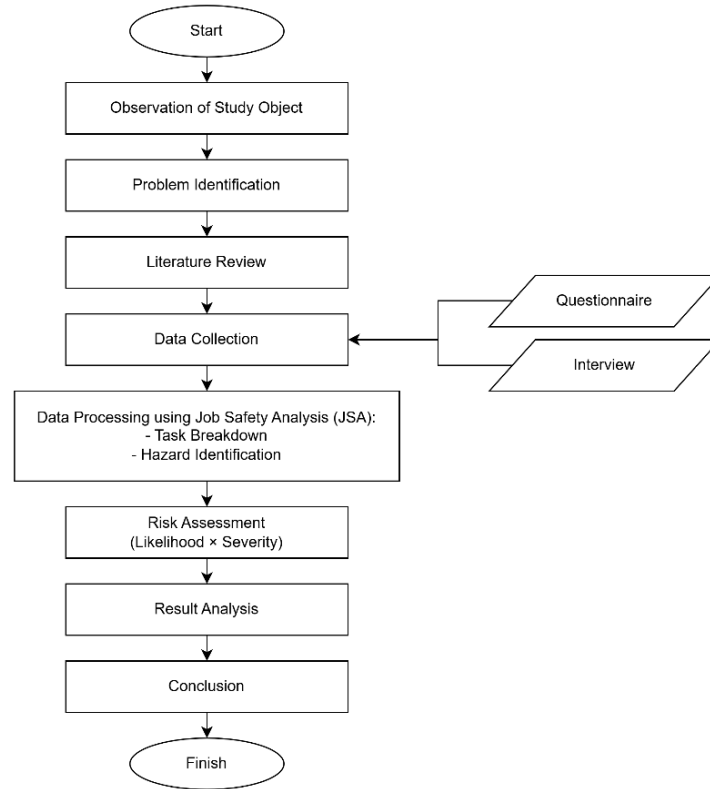


Figure 3. Research Flow Diagram

During the literature review stage, we collect references related to the research problem to establish the study's position and support the analytical process. The subsequent stage involves data collection through interviews, questionnaires, and literature review. The collected data are then processed using the Job Safety Analysis method to determine the risk values associated with each step of the sorting process. These results are further analyzed to assess the level of risk for each work activity, which serves as the basis for drawing conclusions and formulating recommendations. The risk assessment process in this study is conducted by systematically quantifying risk through the multiplication of the likelihood of occurrence and the severity of its potential impact. This approach provides a structured method for evaluating and prioritizing risks based on their overall impact within the work environment.

The data used in this study consists of both primary and secondary data. Primary data were obtained through direct observation in the cold storage warehouse and interviews using a Job Safety Analysis (JSA) questionnaire. Respondents were selected using purposive sampling, focusing on workers directly involved in sorting activities, including floor supervisors (leaders) and operational staff. The selection also considered work experience, with respondents having at least one year of experience, ensuring adequate understanding of work processes, operational procedures, and potential risks at each stage of the activity. Respondents' list, as can be seen in Table 1. The questionnaire used in this study was structured around the Job Safety Analysis (JSA) framework and organized into distinct sections: respondent identity (name, position, and tenure), a breakdown of each work stage in the sorting (*shiwake*) process, an open-ended hazard identification section, and a risk scoring section where respondents rated each identified hazard using two 1-5 scales: likelihood and severity, based on the AS/NZS 4360:2004 standard. A final section captured existing or recommended control measures from the respondent's perspective. Questionnaires were administered through guided, face-to-face sessions combined with semi-

structured interviews with all eight respondents (four leaders and four staff), rather than as self-completed forms, to ensure consistent understanding of the risk scale definitions and minimize interpretation bias across participants.

The scoring process followed a sequential approach: researchers first explained each work stage based on prior field observation, respondents then identified hazards relevant to that stage from their own experience, and finally assigned likelihood and severity scores for each hazard. Since these scores are inherently qualitative judgments converted into numerical values, the eight individual ratings for each hazard were aggregated using the Geometric Mean rather than a simple arithmetic average, as this method reduces the influence of extreme or outlier scores arising from subjective variation among respondents, producing a more stable value that better reflects group consensus [13]. This design was further justified by the adoption of the 1-5 scale to maintain consistency with the AS/NZS 4360:2004 standard used in comparable prior studies [14], the use of guided administration over unassisted self-reporting given respondents' varying familiarity with technical risk-management terminology, and the purposive selection of leaders and staff with at least one year of tenure, based on the assumption that meaningful risk assessment requires practical, first-hand understanding of the actual workflow rather than procedural knowledge alone.

Table 1. Respondent Profile

No.	Initials	Job Title	Years of Experience
1	I	Leader	2
2	F	Leader	1
3	S	Leader	1
4	NM	Leader	2
5	HY	Staff	10
6	OU	Staff	6
7	TH	Staff	2
8	G	Staff	2

In addition to primary data, this study also utilizes secondary data obtained through a literature review of company documents and relevant previous studies to establish a strong theoretical foundation. This study adopts the AS/NZS 4360:2004 risk management standard, as referenced by [14], to determine the scales of probability and severity. The use of this international standard aims to ensure consistency and reliability in evaluating various risk scenarios.

Table 2. Likelihood (LK) Scale

Level	Likelihood	Definition
5	Almost Certain	An event that can occur at any time.
4	Likely	May occur periodically or frequently.
3	Possible	Could occur under certain conditions.
2	Unlikely	Rarely occurs during normal operations.
1	Rare	Very unlikely to occur.

Source: AS/NZS 4360:2004 Risk Management Guideline [14]

Table 3. Severity (SV) Scale

Level	Severity	Definition
1	Insignificant	No injury, very minor financial loss
2	Minor	Minor injury requiring first aid, small financial loss
3	Moderate	Moderate injury requiring medical treatment, moderate financial loss.

Level	Severity	Definition
4	Major	Serious injury (one person), loss of body function, major operational disruption
5	Catastrophic	Fatality (>1 person), major financial loss, widespread impact, total shutdown of operations

After the data were collected through questionnaires from respondents, the next stage involved processing the data to determine the values of probability (likelihood) and severity. Considering that risk assessment is qualitative in nature but converted into numerical values, the geometric mean (Geomean) method was used to aggregate the respondents' answers. This method was selected due to its ability to minimize the influence of extreme values (outliers), resulting in a more stable and representative average that reflects group consensus [13]. The calculated geometric mean values were then rounded to the nearest integer to align with the predefined likelihood and severity scales. Once single values for both parameters were obtained, the risk level was evaluated by calculating the Risk Rating (RR) by multiplying LK and SV.

Table 4. Risk Analysis Matrix

Likelihood (LK)	Severity (SV)				
	1	2	3	4	5
5	High	High	Extreme	Extreme	Extreme
4	Medium	High	High	Extreme	Extreme
3	Low	Medium	High	Extreme	Extreme
2	Low	Low	Medium	High	Extreme
1	Low	Low	Medium	High	High

Source: AS/NZS 4360:2004 Risk Management Guideline [14]

Description:

- Low Risk = The risk is acceptable. No additional control measures are required.
- Medium Risk = Actions are required to reduce the risk; however, the cost of preventive measures should be carefully evaluated and limited.
- High Risk = The activity must not be carried out until the risk is reduced. Immediate risk management actions are required.
- Extreme Risk = The activity must not be carried out or continued until the risk is reduced. If risk reduction is not feasible, the work must be stopped immediately.

This numerical score serves as an indicator of the urgency of mitigation, where higher values represent more critical risks requiring immediate action, while lower values can be managed through routine monitoring. A complete matrix explaining the risk analysis is shown in Table 4. According to the AS/NZS 4360 standard, risk levels are classified into several categories, namely low, medium, high, and extreme. This classification serves as a basis for determining risk control priorities and allocating resources effectively to maintain occupational health and safety in the warehousing environment.

3. Result and Discussion

The analysis of occupational risks using the Job Safety Analysis (JSA) method in operational activities within the observed logistics warehouse in Atsugi resulted in a comprehensive risk assessment by identifying various potential hazards, their severity, likelihood of occurrence, and corresponding Risk Rating (RR) scores. All RR values in this study were calculated based on observations and evaluations of sorting (*shiwake*) activities carried out in the cold storage environment. The classification of risk levels refers to the AS/NZS 4360:2004 standard matrix to ensure consistency and reliability in the evaluation process. Before conducting hazard identification and risk assessment, a thorough understanding of the operational workflow is essential to accurately map potential risks at each stage. The sorting (*shiwake*) activity in the warehouse involves a series of processes that include interactions between manual labor, the use of scanning technologies, and the movement of material handling equipment. The systematic workflow of these activities in the warehouse (Figure 4), from goods arrival to outbound preparation, is illustrated in the following Figure 5.

Based on the operational stages that have been visualized, an in-depth analysis was conducted for each work step to map potential hazards arising at every transition of activities. The breakdown of tasks into smaller activity units is essential in the Job Safety Analysis (JSA) method to ensure that all risks, whether mechanical, ergonomic, or environmental, are comprehensively identified. The results of hazard identification, risk level assessment based on likelihood and severity parameters, and the formulation of control measures for sorting activities are presented in detail in the following Table 5.

Results show a total of 11 potential hazards were identified, encompassing mechanical, ergonomic, and environmental aspects. The risk classification indicates a variation in risk levels, ranging from low to extreme. Extreme risks were identified in two main activities: interaction with forklift traffic in the sorting area, which recorded the highest Risk Rating (RR) value of 16, and direct exposure to extreme temperature environments (cold storage), with an RR value of 12. These risks are categorized as extreme due to their potential to cause severe physical injuries, fatalities, and serious health conditions such as hypothermia.

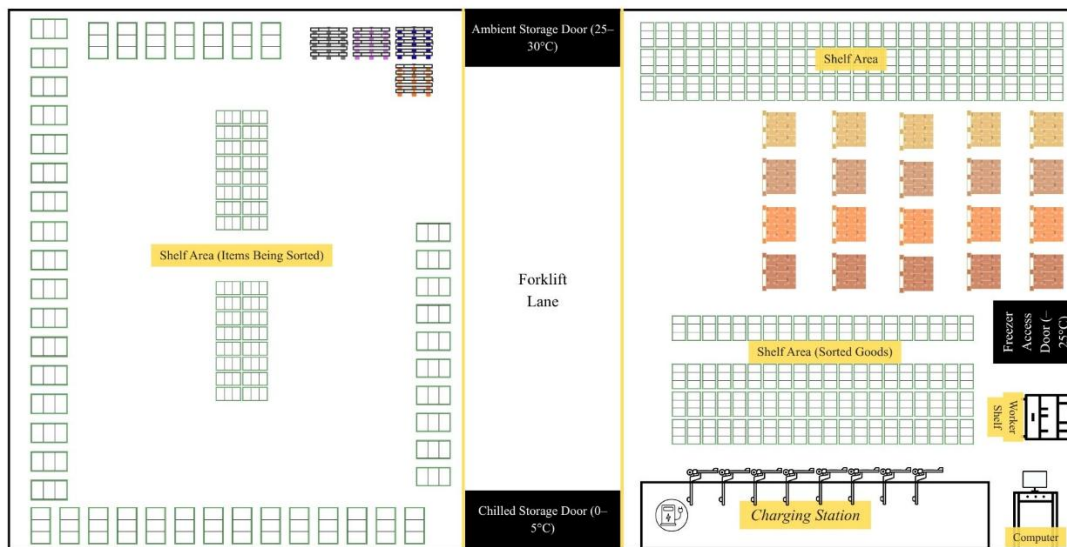


Figure 4. Warehouse Layout

The dominance of forklift traffic as the highest-rated hazard can be attributed to the confined layout of the sorting area, where pedestrian and vehicle pathways are not physically separated, combined with reduced visibility caused by low-temperature condensation forming on protective eyewear and scanner screens. This convergence of spatial constraint and impaired sensory perception elevates both the likelihood and severity of collision events beyond what would typically be observed in ambient-temperature warehouses. Similarly, direct exposure to extreme cold is classified as extreme not only due to the risk of hypothermia itself, but because sustained low-temperature exposure progressively impairs manual dexterity and cognitive alertness. This creates a compounding effect that increases the likelihood of secondary incidents such as dropped loads or delayed reaction to moving equipment rather than acting as an isolated hazard confined to health outcomes alone.

In addition to extreme risks, several activities fall into the high-risk category ($RR \geq 9$), including non-ergonomic working postures such as repetitive bending ($RR = 12$), manual handling of heavy loads ($RR = 12$), and wet or slippery floor conditions in the cold storage area ($RR = 9$). Environmental factors, such as prolonged exposure to low temperatures, also present a high level of risk ($RR = 9$), as they may reduce worker concentration and increase the likelihood of human error. Meanwhile, moderate risks were identified in activities such as the use of manual trolleys ($RR = 8$) and unstable stacking of goods ($RR = 6$), while the lowest risk level was associated with exposure to the handheld scanner screen light ($RR = 4$).

Notably, these four high-risk activities are not independent of one another but are mechanistically linked by the cold storage environment itself. Prolonged cold exposure reduces peripheral blood flow and finger dexterity [15], compelling workers to compensate with awkward gripping and bending postures during manual handling, which in turn elevates the severity of musculoskeletal strain associated with repetitive bending and heavy lifting. At the same time, the temperature differential between the cold storage interior and adjacent areas generates floor condensation, directly contributing to the slip-related risk. This same thermal stress additionally impairs sustained

attention, meaning that a worker already fatigued by cold exposure is simultaneously more prone to misjudging floor conditions or lifting technique. In this sense, low temperature functions as a common root cause that amplifies several seemingly separate hazards rather than acting as one hazard among many.

Overall, these findings indicate that although the warehouse technology system operates efficiently, the presence of high and extreme risks in sorting activities requires immediate attention and systematic mitigation measures. Therefore, risk control strategies are prioritized based on the highest Risk Rating values without neglecting other potential hazards. Mitigation efforts primarily focus on high-to extreme-risk activities, particularly forklift traffic interactions in the sorting area (RR = 16), which pose significant risks of collisions or struck-by incidents. Control measures include the separation of forklift and pedestrian pathways, installation of warning signs, clear marking of operational routes, implementation of speed limits, and the use of reflective safety vests to improve worker visibility.

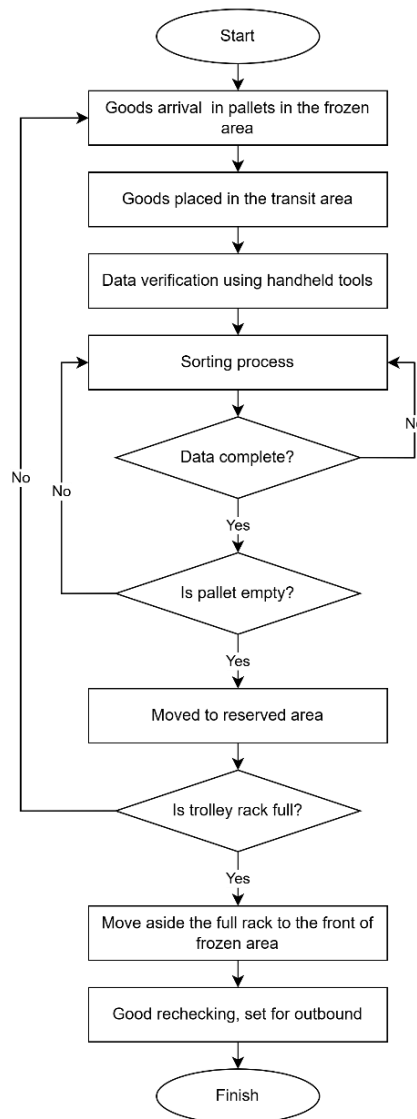


Figure 5. Warehouse Activity Workflow

Ergonomic risks due to repetitive bending postures are addressed through limiting continuous working durations, implementing cycle-based micro-breaks, and job rotation among workers. Training on proper lifting techniques is also essential to reduce musculoskeletal disorders. For manual handling of heavy loads, control measures include limiting lifting weights, utilizing assistive equipment such as trolleys or pallet jacks, and distributing workloads evenly among workers. To mitigate risks associated with extreme cold exposure in cold

storage areas, control measures include the mandatory use of cold-resistant personal protective equipment (PPE), regulation of working durations, and provision of rest periods in normal temperature areas. These measures aim to prevent health issues such as hypothermia and maintain worker concentration.

In addition to primary mitigation strategies based on Risk Rating, previous studies highlight the effectiveness of administrative and visual controls in cold storage environments. Prolonged exposure to cold temperatures has been shown to reduce concentration and increase physical fatigue [16]. Therefore, job rotation and scheduled micro-breaks are recommended as effective and cost-efficient control measures. Visual management practices, such as floor markings, safety signage, and clear separation between forklift and pedestrian pathways, have also been proven to reduce accident risks due to human error [17]. Furthermore, short practical ergonomic training sessions (toolbox meetings) are recommended to enhance workers' understanding of safe working postures [18]. Additional controls include standardizing pallet stacking and clearly marking transit areas to prevent falling object hazards and maintain workplace organization [11].

Table 5. Risk Analysis Matrix

No.	Activity	Hazard	Risk	LK	SV	RR
1	Sorting process in the warehouse	Forklift traffic in the sorting area	ECollision/struck-by incidents causing serious injury or fatality	4	4	16
2		Movement of trolleys or manual carts	A collision causing bruises or minor injuries to the extremities	4	2	8
3		Wet or slippery floor conditions	Slips/falls causing dislocation or head injury	3	3	9
4		Exposure to the handy scanner screen, light & low lighting	Eye strain and reduced visual acuity	2	2	4
5		Extreme operational temperature (0-10°C)	Reduced motor function and numbness in fingers	3	3	9
6		Non-ergonomic working posture (repetitive bending)	Lower back pain (LBP) or musculoskeletal disorders	4	3	12
7		Prolonged exposure to cold temperatures (environmental factor)	Decreased concentration and increased risk of human error	3	3	9
8		High or unstable stacking of goods/boxes	Falling objects causing head or shoulder injury	3	2	6
9		Repetitive manual handling of heavy loads	Shoulder joint injury or muscle cramps due to excessive workload	4	3	12
10		Manual handling of empty pallets	Hands caught in pallets, causing cuts or finger fractures	3	3	9
11		Extreme cold working environment (Cold Storage)	Hypothermia or frostnip on exposed skin	4	3	12

Overall, these additional mitigation measures are adaptive, practical, and do not require significant technological investment, making them suitable for integration into the existing operational system. Their implementation is also aligned with the principle of continuous improvement in occupational health and safety management within warehouse environments. The feasibility analysis indicates that most recommended controls are administrative and visual in nature, making them relatively easy to implement without disrupting operations. However, potential challenges include operational disruptions during peak hours, worker compliance with administrative policies, and balancing mitigation effectiveness with operational costs.

4. Conclusion

Based on the results of this study using the Job Safety Analysis (JSA) method on sorting (*shiwake*) activities in the observed logistics warehouse in Atsugi, Japan, it can be concluded that working activities in cold storage environments involve varying levels of occupational health and safety risks, ranging from low to extreme. Among the 11 identified hazards, the highest risk was associated with forklift traffic interaction in the sorting area, with a Risk Rating (RR) of 16, categorized as extreme due to its potential to cause severe injury or fatality. In addition, prolonged exposure to cold environments, repetitive manual handling of heavy loads, and non-ergonomic working

postures were identified as high-risk factors, with RR values ranging from 9 to 12. These risks may lead to musculoskeletal disorders, decreased concentration, and serious health conditions such as hypothermia. Moderate risks were found in manual trolley use and unstable stacking conditions, while low risks were associated with exposure to handheld scanner screens and lighting conditions.

The likelihood and severity calculations, processed using the geometric mean method, indicate that cold environmental conditions, high physical workload, and interactions between workers and material handling equipment are the primary contributors to occupational risks. Therefore, the proposed mitigation measures include the provision and standardization of appropriate PPE for cold storage environments, regulation of working hours and rest periods, implementation of job rotation, enhancement of ergonomic and manual handling training, clear separation of forklift and pedestrian zones, and maintenance of floor and environmental conditions to prevent slips and falls. The integrated and risk-based implementation of these mitigation strategies is expected to reduce workplace accidents, improve worker comfort and health, and support the creation of a safe, productive working environment aligned with the zero-accident principle.

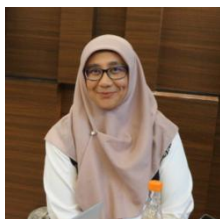
For future research, it is recommended to expand the risk analysis by combining JSA with other methods such as HIRARC, FMEA, or quantitative ergonomic approaches like RULA or REBA to obtain more comprehensive results. Additionally, future studies may extend the scope beyond sorting activities to include inbound and outbound processes for a more holistic risk assessment. Further research may also evaluate the effectiveness of the proposed mitigation strategies through before-and-after analysis or periodic safety performance assessments.

References

- [1] H.W.W. Pitoy, A.B.H. Jan, J.S.B. Sumarauw, Analisis Manajemen Pergudangan pada Gudang Paris Superstore Kotamobagu, *Jurnal EMBA* 8 (2020) 252–260.
- [2] J. Michael, S. Gorucu, Analysis of Forklift and Pallet Jack Injuries in Wood-related Industries, *For. Prod. J.* 70 (2020) 403–408.
- [3] S. Bitzas, S. Ma, K. Pesanelli, A.M. Zaia, Risk Factors and Impacts of Slips, Trips, and Falls in Janitorial Populations: A Literature Review, *Appl. Ergon.* 102 (2022) 103745.
- [4] Y. Wang, X. Wang, Y. Zhang, X. Geng, Research on Risk Factor Filtering and Rating of Cold Chain Logistics from The Perspective of Root-state Risk Identification, *J. Food Sci.* 89 (2024) 1599–1615.
- [5] Ö. Arslan, N. Karakurt, E. Cem, S. Cebi, Risk Analysis in The Food Cold Chain Using Decomposed Fuzzy Set-based FMEA Approach, *Sustainability* 15 (2023) 13169.
- [6] N. Ghani, F. Tariq, H. Javed, N. Nisar, A. Tahir, Low-temperature Health Hazards among Workers of Cold Storage Facilities in Lahore, Pakistan, *Medycyna Pracy. Workers' Health and Safety* 71 (2020) 1–7.
- [7] H. Anttonen, A. Pekkarinen, J. Niskanen, Safety at Work in Cold Environments and Prevention of Cold Stress, *Ind. Health* 47 (2009) 254–261.
- [8] D. Charles, Cold Storage Work and Cold Protective Gloves-A Review, (2020).
- [9] M.Z. Ikhsan, Identifikasi Bahaya, Risiko Kecelakaan Kerja dan Usulan Perbaikan Menggunakan Metode Job Safety Analysis (JSA), *Jurnal Teknologi Dan Manajemen Industri Terapan* 1 (2022) 42–52.
- [10] A. Thetkathuek, P. Meepradit, W. Jaidee, Factors Affecting the Musculoskeletal Disorders of Workers in the Frozen Food Manufacturing Factories in Thailand, *International Journal of Occupational Safety and Ergonomics* 22 (2016) 49–56.
- [11] S.V. Esmaeili, A. Alboghobeish, H. Yazdani, A. Ghasemi Koozekonan, M. Pouyakian, Optimizing In-store Warehouse Safety: A DEMATEL Approach to Comprehensive Risk Assessment, *PLoS One* 20 (2025) e0317787.
- [12] F. Novianti, A. Windriya, Hazard Analysis of Occupational Health and Safety (OHS) Using The JSA (Job Safety Analysis) Method in Grey Weaving 2 Warehouse PT XYZ, *Asian Journal of Logistics Management* 2 (2023) 33–47.
- [13] M. Marozzi, M. Bolzan, S. Di Zio, Robust Weighted Aggregation of Expert Opinions in Futures Studies, *Ann. Oper. Res.* 342 (2024) 1471–1493.
- [14] B.P. Pratama, A. Suryadi, Penggunaan Metode Job Safety Analysis untuk Mengurangi Risiko Kecelakaan Pekerjaan Ketinggian Penggantian Kabel Elevator Lift di PT XYZ, *Jurnal Serambi Engineering* 10 (2025).
- [15] S.S. Cheung, Responses of the Hands and Feet to Cold Exposure, *Temperature* 2 (2015) 105–120.

- [16] F. Ghasemi, A. Doosti-Irani, H. Aghaei, Applications, Shortcomings, and New Advances of Job Safety Analysis (JSA): Findings from A Systematic Review, *Saf. Health Work* 14 (2023) 153–162.
- [17] A. Cantini, F. De Carlo, M. Tucci, Towards Forklift Safety in A Warehouse: An Approach Based on The Automatic Analysis of Resource Flows, *Sustainability* 12 (2020) 8949.
- [18] Y.S. Zhao, M.H. Jaafar, A.S.A. Mohamed, N.Z. Azraai, N. Amil, Ergonomics Risk Assessment for Manual Material Handling of Warehouse Activities Involving High Shelf and Low Shelf Binning Processes: Application of Marker-based Motion Capture, *Sustainability* 14 (2022) 5767.

Biographies of Authors



Yelita Anggiane Iskandar completed her bachelor's degree in Industrial Engineering from the Universitas Indonesia in 2007 with a concentration in system modeling. In 2013, she obtained a master's degree from the Institut Teknologi Sepuluh Nopember (ITS) in Surabaya, East Java, Indonesia, in the field of logistics and supply chain management, with cum laude predicate. Currently pursuing a doctoral degree in Industrial Engineering, especially in the area of scheduling at Pusan National University, South Korea, while also actively working as a lecturer at the Study Program of Logistics Engineering at Universitas Pertamina, Jakarta. Previously, she worked at PT Freeport Indonesia in Tembagapura, Papua, in the Maintenance Department, and at PT Fonterra Brands Indonesia in Jakarta, handling product import and supply planning.



Bathara Hananta Ramdhan was born on November 20th, 2002. He completed his high school education at SMA Negeri 10 Kota Bogor. Currently, he is a student of the Logistics Engineering Department at Universitas Pertamina. As a part of the Merdeka Belajar Kampus Merdeka (MBKM) program, he is currently taking an industrial internship at Shimohana Logistics, Atsugi Branch, Japan.



Lana Salsabila Muhyi was born in Probolinggo on May 2nd, 2004. She completed her elementary education at SD Sebaung 1 in 2017 and graduated from SMPN 1 Kraksaan in 2019 through an accelerated program. She then continued her secondary education at MBI Amanatul Ummah and graduated in 2022. Currently, she is a student in the Department of Logistics Engineering at Universitas Pertamina. As part of the MBKM (Merdeka Belajar Kampus Merdeka) program, she is currently undertaking an industrial internship at Shimohana Logistics Atsugi Center in Japan.



Rahma Alia Azzahro was born on February 18th, 2004. She completed her elementary education at SDN Krian 4 in 2016, followed by her junior high school at SMP BP Amanatul Ummah, graduating in 2019. She then pursued her senior high school education at MBI Amanatul Ummah and graduated in 2022. She is currently an undergraduate student in the Department of Logistics Engineering at Universitas Pertamina. Her academic interests include logistics operations and supply chain management.



Winda Septiana, often called Winda, is the child of the couple Agus Rianto and Siti Aminah, who was born on September 25th, 2003. After graduating from Tlumpu Public Elementary School in 2016, she continued his education at Public Junior High School 02, Blitar City in 2019. Then she studied at SMAN Taruna Nala and graduated in 2022. Winda is a 1st grade student at the Department of Logistics Engineering, Universitas Pertamina.