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REDUCING PROCESSING DELAYS IN MDA STICKER LABELLING: A QUALITY TOOLS APPROACH IN MALAYSIAN WAREHOUSE OPERATIONS

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Abstract: Efficient warehouse operations are crucial for maintaining smooth supply chain performance, particularly in the medical device sector where regulatory compliance is stringent. In Malaysia, adherence to the Medical Device Authority (MDA) labelling requirements is a mandatory step before product distribution, underscoring the need for both accuracy and timeliness. However, operational challenges such as limited staging space can hinder workflow, cause bottlenecks, and affect overall productivity. This study investigates the operational inefficiencies arising from limited staging space during the MDA sticker labelling process in a Malaysian warehouse. Data from 18 labelling activities were analysed using quality tools such as Pareto analysis, fishbone diagrams, and the Five Whys technique to identify the root causes of processing delays. The findings reveal that inadequate staging space significantly contributes to workflow bottlenecks and prolonged waiting times. Recommendations are provided to address these issues through layout optimisation and process standardisation. The study offers practical insights for warehouse managers and logistics practitioners seeking to enhance operational performance and regulatory compliance within Malaysia's medical device distribution network.

Keywords: MDA Labelling Process, Warehouse Efficiency, Staging Space Constraints, Cause-and-Effect Analysis, Medical Device Distribution

1. Introduction

The regulation and management of medical devices are vital to ensuring their safety, efficacy, and quality within the healthcare sector. In Malaysia, the Medical Device Authority (MDA) serves as the primary regulatory body overseeing the registration, approval, and monitoring of medical devices. Since its establishment, the MDA has played a pivotal role in

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

safeguarding public health by enforcing stringent standards and compliance measures (Medical Device Authority [MDA], 2018). It also provides guidance on the application of drug–medical device and medical device–drug combination products, thereby supporting the safe integration of such products in healthcare settings (MDA, 2021).

A key component of medical device regulation is labelling**,** which conveys essential information and instructions regarding a device's intended use, precautions, instructions, warnings, and other details necessary for safe and effective operation (MDA, 2021). Since 2012, all medical devices registered in Malaysia must display a Medical Registration Number on their labels to ensure traceability and authentication, thus distinguishing genuine products from counterfeit ones. The MDA registration sticker, typically affixed to each product, provides visible proof of compliance with regulatory requirements (MDA, 2018).

The MDA's labelling regulations are fundamental in maintaining the integrity of medical devices throughout their lifecycle. Under the Medical Device Act 2012 (Act 737) and the Medical Device Regulations 2012**,** labelling standards are designed to ensure that both healthcare professionals and patients have access to accurate and reliable information, thereby promoting the safe and effective use of devices (MDA, 2018).

In addition to labelling, adherence to Good Manufacturing Practice (GMP) and Good Distribution Practice (GDP) guidelines is crucial for sustaining product quality. Good Manufacturing Practice guidelines ensure that manufacturing processes are consistently controlled and compliant with quality standards, encompassing facility design, access control, cleanliness, and dedicated quality control areas (National Pharmaceutical Regulatory Agency [NPRA], 2008). Meanwhile, GDP focuses on ensuring that medical devices are handled, stored, and transported under conditions that preserve their integrity and prevent contamination or degradation during distribution (NPRA, 2008).

This study investigates the MDA labelling process in Malaysia, with a focus on identifying the root causes of delays and assessing the impact of limited staging space on operational efficiency. By analysing current practices and workflow constraints, the study aims to propose strategies to minimise bottlenecks, enhance process efficiency, and strengthen compliance with regulatory standards. Improvements in the labelling process are not only essential for ensuring device quality and patient safety but also for sustaining public confidence in the healthcare system.

2. Literature Review

This section presents key themes relevant to warehouse efficiency and labelling, focusing on space optimisation, the operational implications of limited space, and methods for identifying process delays. It begins by observing warehouse space optimisation techniques, followed by a discussion on how spatial constraints affect workflow efficiency, particularly in labelling processes. The review then highlights approaches used to identify bottlenecks and inefficiencies in warehouse operations.

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

2.1 Warehouse Space Optimisation

Optimising warehouse space is a central concern in warehouse management, especially for operations with limited storage capacity. Prior studies have explored various strategies to maximise efficiency through improved layout design, innovative space utilisation, and technological solutions. Živičnjak et al. (2022) explored warehouse efficiency enhancement through product categorisation (ABC, XYZ), redesigning storage spaces with narrow aisles, and optimising transport routes. These measures are aimed at reducing order-picking time and increasing storage capacity, although their study was limited to three similar warehouses and was affected by measurement subjectivity. Future studies could expand the sample to include diverse warehouse types and consider seasonal variations in operations.

Similarly, Rebelo et al. (2021) employed descriptive, analytical, and hypothetical-deductive methods to propose design improvements such as additional bins and cantilever beams, achieving a 9.77% increase in capacity. However, incomplete material dimension data and potential inaccuracies from group discussions limited the study's precision. Perera and Fernando (2021) addressed warehouse design complexity using data mining, simulation models, linear programming (LP), and goal programming (GP), providing systematic approaches for warehouse optimisation. They emphasised the need to consider vertical stacking and object heterogeneity in future research.

Fumi et al. (2013) introduced a vertex colouring problem (VCP) approach to address the storage location assignment problem (SLAP). Their multi-product slot-code optimisation heuristic method reduced warehouse space requirements by 24%, though it was limited by its focus on a dedicated storage policy. Broader exploration of diverse storage systems could yield more comprehensive insights into space utilisation and efficiency enhancement.

2.2 Impact of Limited Space on Warehouse Operations

Limited warehouse space significantly affects operational efficiency, particularly in relation to workflow, material flow, and labelling processes. The objective is to understand the impact of spatial constraints on warehouse efficiency and to explore how labelling intersects with these challenges. Okur (2024) noted that transitioning to storage systems with new technology and solid-frame racks may inadvertently reduce productivity when spatial constraints persist. Inadequate space often leads to goods being stored along communication routes, which obstructs access and increases the risk of damage, thereby complicating operations and reducing employee efficiency.

The Theory of Constraints (TOC) offers a useful framework for managing such limitations. Lewandowska-Ciszek (2018) applied the TOC's *Five Focusing Steps Principle* by identifying, exploiting, and elevating constraints to improve warehouse performance by addressing issues in picking and storage areas. Similarly, Adam Mohd Saifudin et al. (2013) demonstrated that warehouse layout and an effective Management Information System (MIS) are critical determinants of operational efficiency, particularly for small and medium enterprises (SMEs).

Selangor Business Review

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Opoku et al. (2020) investigated spatial constraints in Ghanaian manufacturing firms, highlighting that efficient inventory management and layout configurations reduce operational costs and enhance performance. Likewise, Bylka (2020) examined how consignees' warehouse space constraints affect production-distribution cycles and associated costs. They developed a model describing production–distribution cycles under space limitations, showing that constrained warehouse space affects both operational costs and inventory management policies. These studies collectively underscore the need for flexible and adaptive space management strategies to maintain warehouse efficiency.

2.3 Delay Identification

Identifying the causes of delay is essential for improving warehouse performance, particularly in space-limited environments. Jum'a and Basheer (2023) investigated inefficiencies in value-added services (VAS) within non-automated third-party logistics (3PL) warehouses highlighting issues such as unclear timetables, poor space utilisation, and high employee turnover. Using Pareto analysis, they identified such issues and high employee turnover, and recommended enhanced training and automation to address these challenges.

Suárez-Barraza and Rodríguez-González (2019) applied the cause-and-effect (Ishikawa) diagram in logistics operations to improve decision-making, demonstrating how tools such as the *Five Whys* and *5W2H* methods can effectively analyse root causes affecting service quality. Similarly, Gupta and Kumar (2015) employed Pareto charts, fishbone diagrams, and the Analytical Hierarchy Process (AHP) to prioritise root causes of HDPE bag damage in the carbon black industry, leading to targeted corrective actions that reduced financial losses. Tsou and Hsu (2022) further improved warehouse operations using the Fishbone Diagram and DEMATEL technique to analyse interdependencies among factors influencing performance in the handling of imported components. Their study showed that integrated analytical tools can support more strategic decision-making in warehouse management.

Table 1 summarises key studies on warehouse space optimisation and delay identification. It highlights the techniques used, such as Pareto analysis and cause-and-effect diagrams and presents their findings. This overview helps identify effective strategies and gaps relevant to this study.

Table 1**:** Summary of key studies on warehouse space optimization and delay optimization.

Author(s)	Journal	Technique(s)	Findings
Živičnjak et al. (2022)	*Transportation Research Procedia*	Product categorisation (ABC, XYZ), redesign of storage spaces	Enhanced warehouse efficiency by reducing order-picking time and increasing storage capacity. Limited by the focus on similar warehouses and subjectivity in measurements.
Rebelo et al. (2021)	*Procedia Manufacturing*	Descriptive, analytic, and	Proposed changes, like new bins and cantilever beams, to

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

		hypothetical-deductive methods	increase capacity by 9.77%. Accuracy constrained by incomplete material data and potential discussion inaccuracies.
Perera et al. (2022)	*Sri Lanka Journal of Economics, Statistics, and Information Management*	Data mining, simulation models, LP, GP	Systematic approaches to warehouse optimization. Need for addressing vertical stacking and heterogeneity of stored objects.
Fumi et al. (2013)	*International Journal of Engineering Business Management*	Vertex colouring problem (VCP) approach	Reduced required warehouse space by 24% through multi-product slot-code optimization. Limited exploration of alternative storage policies.
Lewandowska-Ciszek (2018)	*Management and Production Engineering Review*	Theory of Constraints (TOC)	Identified impact of technology on productivity and space management. Suggested TOC's Five Focusing Steps Principle to optimise warehouse operations.
Adam Mohd Saifudin et al. (2013)	In: *4th International Conference on Education and Information Management*	Warehouse layout analysis, MIS	Effective layout and MIS crucial for high operational efficiency in SMEs.
Bylka (2020)	*International Journal of Production Research*	Model for production-distribution cycles	Developed a model to manage space constraints and their impact on inventory management policies.
Jum’a & Basheer (2023)	*Administrative Sciences*	Pareto analysis	Identified inefficiencies in VAS in non-automated 3PL warehouses, recommending improved training and automation.
Suárez-Barraza & Rodríguez-González (2019)	*International Journal of Quality and Service Sciences,*	Cause-and-effect diagram (Ishikawa), "Five Whys", "5W2H"	Identified factors affecting logistics service quality and analysed root causes using the Ishikawa method and supplementary tools.

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Gupta & Kumar (2015)	*Proceedings of 3rd International Conference on Reliability, Infocom Technologies and Optimization*	Pareto charts, fishbone diagrams, AHP	Prioritized root causes of HDPE bag damage and developed solutions to reduce financial losses in the carbon black industry.
Tsou & Hsu (2022)	*China-USA Bus. Rev*	Fishbone Diagram, DEMATEL technique	Analysed interdependent factors affecting warehouse operations for imported components and suggested improvements based on DEMATEL analysis.

3. Research Methodology

3.1 Project Duration, Software Utilisation, and Resource Allocation

The research was undertaken between April 2023 and September 2023 and involved a total of eight personnel: a reach truck driver, a labelling team comprising a team leader and four members, a quality inspector, and a clerk. The study was conducted within a selected pharmaceutical company located in Shah Alam. Key milestones encompassed data collection during both the pre-improvement and post-improvement phases. The labelling team leader systematically recorded the duration of activities using a stopwatch, the reach truck driver was pre-alerted regarding incoming arrivals to minimise operational delays, and the quality inspector conducted regular inspections to ensure the continuity and efficiency of operations.

Microsoft Excel was employed for data tabulation and the execution of Pareto analysis, while Microsoft Visio was utilised to construct fishbone diagrams for root cause identification. Each analytical tool served a specific and complementary function, thereby enhancing the rigour and validity of the research process.

3.2 Data Collection

The primary objective of the data collection is to develop a Pareto chart to identify labelling activities that consume the greatest amount of time. In line with the 80/20 rule, the chart illustrates that approximately 80% of the total time is attributable to around 20% of the labelling activities, thereby highlighting the unequal distribution of time consumption across the process. In this case study, a total of 18 processes are involved in the MDA sticker labelling operation. The labelling workflow begins once picked pallets are delivered from the high rack. Specifically, timing commences when the reach-truck driver completes the picking activity and pallets are temporarily parked in the aisle while awaiting transport to the cargo lift. This "parking" period ends when the pallets are moved to the pre-labelling area.

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

At the pre-labelling area, a staff member conducts a rapid stock count of loose cartons only to reconcile quantities against the Goods Received Note (GRN). The counting time starts at the commencement of counting and ends when the quantities match the GRN. Subsequently, the pallets are loaded onto the cargo lift, and the allocation time concludes only once the aisle is fully cleared. Next, the pallets are unwrapped, with unwrapping time measured from the first cut to the removal of the final wrapping. Two personnel then sort the cartons into batches based on the batch document, with sorting time recorded from start to completion. While sorting is in progress, a physical inspection is carried out to identify any visible damage, and samples are taken for quality assurance (QA) testing. The inspection time is measured from the first inspection to the collection of the final sample.

Both outer carton stickers and batch stickers are then counted and matched to the relevant products, with the duration recorded as packaging-counting time. A mock-up (golden sample) is subsequently prepared as the reference for labelling. Mock-up preparation time is measured from the start of preparation to handover to QA, while QA's approval time is recorded from receipt of the mock-up to formal sign-off. Following approval of the golden sample, MDA labels are affixed to the products, with the elapsed time recorded from the application of the first to the last MDA label. Batch labelling immediately follows, with time measured from the first to the final batch label applied. Upon completion of labelling, an In-Process Quality Check (IPQC) is conducted, and the operator completes the IPQC form. The inspection-and-documentation time is measured from the moment the operator begins filling in the form until completion, including the recording of any issues.

Thereafter, the batch document is completed, stamped, and signed, with the duration measured from document initiation to the final signature. QA then performs final sampling on each pallet and provides verification through stamping and signing. The final release time encompasses the sampling process through to QA sign-off. Once QA has released the goods, the pallets are moved to the post-staging area and transported downstairs via the cargo lift. Movement time is measured until the pallets reach the lift and depart the staging area. Each pallet is then put away in the system using an RF gun, with time recorded per pallet until all bins are registered. The physical put-away process is completed when each pallet is secured in its designated bin, as confirmed in the system.

Each activity has clearly defined start and end points, allowing the total labelling lead time to be calculated by summing the measured durations from allocation at the pre-labelling stage through to QA final release. This constitutes the core labelling window (unwrapping → sorting → inspection → counting → mock-up preparation and approval → MDA and batch labelling → IPQC → batch documentation → QA final release). Upstream activities (picking and parking) and downstream activities (post-staging, transport, and system put-away) add transport and system registration time to the overall process. Accordingly, all activities were included in this study. Table 2 summarises the processes and their respective time descriptions.

Selangor Business Review

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Table 2: The labelling process and description of time taken

Step	Process	Description
1	Picking stock at high rack	Time starts when the reach truck driver picks the stock and ends once the picking is completed.
2	Stock parked temporarily at aisle	Time starts once the pallets are arranged in the aisle, awaiting transport to the cargo lift.
3	Stock counting after picking	Count stock to match the Good Received Note (GRN), counting only loose cartons to speed up the process.
4	Stock allocated at pre-labelling area.	Time starts when stock is moved to the cargo lift and ends when all pallets are clear from the aisle.
5	Remove Wrapping	Time starts when pallets are unwrapped and ends when the wrapping is completely removed.
6	Sorting by batches	Two personnel sort stock based on batch document; time is measured from start to completion.
7	Physical stock inspection	Stock is checked for damage, and samples are taken for inspection. Time measured from start to completion.
8	Counting material packaging	Count outer carton stickers (e.g., MDA and batch stickers) and match with the product.
9	Mock-up preparation (Golden Sample)	Prepare a golden sample as a reference for the labelling process. Time measured from preparation to handover to Quality Assurance (QA).
10	Mock-up Approval	Quality Assurance (QA) checks the mock-up unit and approves it based on batch document guidelines.
11	MDA labelling	Measure the time it takes to affix MDA labelling to the product.
12	Batch Labelling	Time is measured for batch labelling after MDA labels are affixed.
13	Complete Inspection of Quality Checking (IPQC)	Worker fills the Inspection of Quality Check (IPQC) form and records abnormalities; time starts and ends with form completion.
14	Complete the batch document	Batch document is completed, stamped, and signed by both worker and management for approval.
15	Final Release from QA	QA performs final sampling checks on each pallet, stamps, and signs for verification.
16	Bring stock to post-staging area	Time is measured as stock is moved from staging to the cargo lift and downstairs for put-away.
17	Put away on system	Pallets are registered in the system, one at a time, using an RF gun until all bins are recorded.
18	Locate the goods stock at the put-away bin	Stock is placed in the designated bin as recorded in the system.

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

3.3 Pareto Chart Guidelines

As summarised in Table 3, the initial step in constructing a Pareto chart is to clearly define the problem, thereby establishing a foundation for systematic analysis. Subsequently, relevant data are collected from appropriate sources such as operational records or survey instruments. In the present study, the recorded time taken for each activity, as detailed in the data table, served as the primary dataset. The third step involves categorising the data, in this case, into 18 distinct MDA labelling activities to facilitate the identification of underlying patterns. Thereafter, the frequency of each activity is computed to determine which tasks consume the greatest proportion of total time. Cumulative frequencies and corresponding percentages are then calculated for each category in accordance with established analytical guidelines.

Once the data have been organised, a Pareto chart is generated, with categories represented along the x-axis and cumulative percentages along the y-axis. The final step entails analysing the chart to identify the critical few activities that contribute most significantly to operational delays, in accordance with the Pareto principle, which posits that approximately 20 per cent of causes account for 80 per cent of the observed effects.

Table 3: Step-by-step to create a Pareto chart. (Gupta & Kumar, 2015)

No	Steps	Explanation
1	Identify the problem or issue to be analyzed	Determine the specific issue or problem that you want to address using the Pareto chart.
2	Collect data	Gather relevant data on the problem, such as the frequency of different types of defects or issues
3	Categorise the data	Group the data into categories or types of issues. This could be based on different types of defects, causes of problems, or any other relevant categories
4	Calculate the frequency or count	Determine the frequency or count of each category of issues in the data
5.	Calculate the cumulative frequency	Calculate the cumulative frequency by adding up the frequencies of the categories from highest to lowest
6.	Calculate the percentage for each category	Determine the percentage that each category represents of the total issues
7.	Create the Pareto chart	Plot the categories on the x-axis and the frequencies or percentages on the y-axis. Additionally, plot the cumulative frequency as a line graph
8.	Analyze the chart	Identify the categories that contribute the most to the overall problem by looking at the tallest bars on the chart. These are the issues that should be prioritized for improvement efforts

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

3.4 Fishbone Diagram Guidelines

Figure 1 illustrates a Fishbone Diagram, also referred to as an Ishikawa Diagram, which is employed to identify the root causes underlying a particular problem. This analytical tool categorises potential causes into six primary domains: Man, Machine, Material, Method, Environment, and Measurement. Such categorisation facilitates a systematic breakdown of factors contributing to inefficiencies or issues within a given process, in this case, the labelling operation.

According to Suárez-Barraza and Rodríguez-González (2019), the Fishbone Diagram serves as an effective instrument for comprehending and visualising complex problems by mapping potential causes in a clear and structured manner. The diagram is constructed by positioning the problem statement (effect) at the "head" of the fish, with the major causal categories extending along the "bones." This visual representation enables teams to pinpoint areas requiring further investigation and to prioritise corrective actions based on the identified root causes.

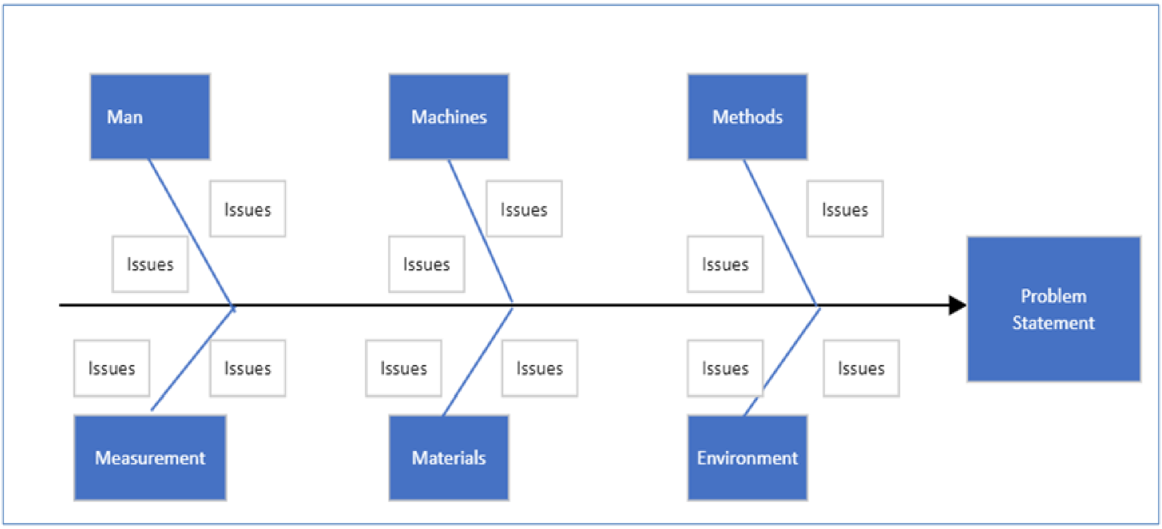

Figure 1: The Fishbone Diagram

The Five Whys method, originally developed by the Japanese industrialist Sakichi Toyoda and subsequently popularised by quality expert Taiichi Ohno, constitutes a systematic approach to problem-solving. Widely adopted across industry, it seeks to identify the root cause of an issue by repeatedly asking the question "Why?", typically five times. The method underpins continuous improvement practices and is frequently applied within the PDCA (Plan–Do–Check–Act) cycle (Nguyen et al., 2023). Table 4 presents a step-by-step outline for applying the Five Whys analysis, detailing each investigative stage and the corresponding corrective action. Adherence to this procedure enables teams to move beyond superficial symptoms to uncover the underlying causes of persistent problems, thereby facilitating the implementation of effective corrective measures.

Selangor Business Review
Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Table 4: Five Whys analysis step by step (PDCA from Theory to Effective Applications (Nguyen et al., 2023)

Step	Action	Explanation
1	Define the Problem	Clearly identify the problem or issue you are facing. This step is critical to ensure that the team is focused on the right problem.
2	Ask the First "Why"	Ask why the problem occurs. This question should identify a surface-level cause, helping to establish a starting point for further investigation.
3	Ask the Second "Why"	Based on the answer to the first "Why", ask why this cause exists. This question digs deeper into the initial cause, looking for underlying factors.
4	Ask the Third "Why"	Continue asking why to explore the next layer of causes. This question helps to further narrow down and identify the root cause.
5	Ask the Fourth "Why"	Repeat the process to go deeper into the causes, if needed. This question helps to uncover additional contributing factors that may not have been identified in previous steps.
6	Ask the Fifth "Why"	If the root cause is not yet clear, continue with the fifth "Why" to investigate further. This will usually reveal the fundamental cause behind the issue.
7	Identify the Root Cause	After asking the necessary number of "Whys", the root cause is identified. This is the underlying factor that caused the problem in the first place.
8	Implement Corrective Action	Once the root cause is identified, develop and implement corrective actions to resolve the issue and prevent it from recurring. This may involve process changes, training, or other interventions.

4. Results and Discussion

The process of *"Bringing Stock to the Pre-Labelling Staging Area"* consistently required the greatest amount of time, peaking at an average of 530 minutes in August and recording an overall average of 358.33 minutes in September. This activity alone accounted for 46.6 per cent of the total labelling time, thereby representing the most significant contributor to process inefficiency. Other time-intensive activities included *MDA Labelling* and *Batch Labelling*, which recorded average durations of 102.00 minutes and 94.53 minutes, respectively, in September. These accounted for 13.6 per cent and 13.3 per cent of the total labelling time. *Final Release from QA* (4.0 per cent) and *Bringing Stock to the Post-Staging Area* (2.7 per cent) also contributed notably to the overall process duration, indicating potential points at which operational delays may occur.

Conversely, activities such as *Counting Stock After Picking*, *Mock-up Preparation*, and *Counting Material Packaging* required substantially less time, each averaging below 10 minutes and contributing less than 1.4 per cent to the total process time. These findings indicate that stock staging, labelling, and quality assurance approval processes constitute the primary areas of concern that warrant improvement initiatives. To facilitate prioritisation, a Pareto analysis was employed to identify the processes that contribute most significantly to time inefficiencies and to determine their relative potential for improvement. Table 5 presents a summary of the time durations associated with each process.

Table 5: Time taken results for Labeling Activities (April - September)

No	Process / activity	Unit of measure	Average April (min)	Average May (min)	Average Jun (min)	Average July (min)	Average Aug (min)	Average Sept (min)	Sum of average (min)	Total labelling activity (%)
1	Picking stock (high rack)	Pallet	15.3	15.0	17.0	6.3	24.0	18.8	96.2	2.6
2	Let down stock (park temporary at aisle)	Pallet	14.3	13.5	13.4	8.2	14.0	13.0	76.7	2.0
3	Counting stock after picking	Case	6.5	6.5	7.5	2.9	8.0	6.3	38.5	1.0
4	Bring stock at pre labelling staging area	Pallet	355.0	166.5	269.5	68.5	530.0	358.3	1747.8	46.6
5	Remove original transparent wrapping stretch from pallet	Pallet	6.4	6.9	6.4	3.0	8.0	6.0	38.0	1.0
6	Sorting based by batches	Ea	13.3	17.8	14.3	4.8	16.0	14.9	80.9	2.2
7	Physical stock inspection	Ea	3.6	5.1	2.9	4.7	5.0	3.9	25.1	0.7
8	Counting material packaging	Ea	7.7	8.2	11.0	3.8	10.7	10.9	52.3	1.4
9	Mock-up preparation	Ea	2.0	4.8	2.0	1.9	1.9	1.9	14.5	0.4
10	Mock-up approval from QA	Ea	2.0	4.0	2.0	1.9	2.4	2.2	14.4	0.4
11	MDA labelling	Ea	85.8	75.5	88.0	37.3	120.0	102.0	508.6	13.6
12	Batch labelling	Ea	84.5	81.5	87.5	31.8	118.0	94.5	497.8	13.3
13	Complete in-process quality checklist (IPQC)	Ea	10.1	10.9	8.6	7.4	13.4	9.5	59.8	1.6

Selangor Business Review
Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

14	Complete and close batch document	Ea	4.6	6.5	6.1	4.1	4.5	5.5	31.2	0.8
15	Bring stock at post staging area	Pallet	16.0	14.5	15.7	6.0	28.0	20.0	100.2	2.7
16	Final release from QA	Ea	26.3	24.50	23.5	11.8	37.0	27.5	150.5	4.0
17	Locate pallet at put away bin	Pallet	21.0	19.5	21.5	13.5	30.0	24.2	129.7	3.5
18	Put away on system	Ea	13.8	20.0	13.0	6.7	20.0	15.4	88.8	2.4

4.1 Results for Pareto chart

Based on the time taken for 18 labelling activities as shown in Table 5, the data were used to construct a Pareto chart (see Figure 2). The purpose of the Pareto chart is to identify the key factors approximately 20% of the causes that account for about 80% of the overall effects (Gupta & Kumar, 2015). The chart reveals that the *vital few* processes, consistent with the Pareto Principle, are those with the highest cumulative percentages.

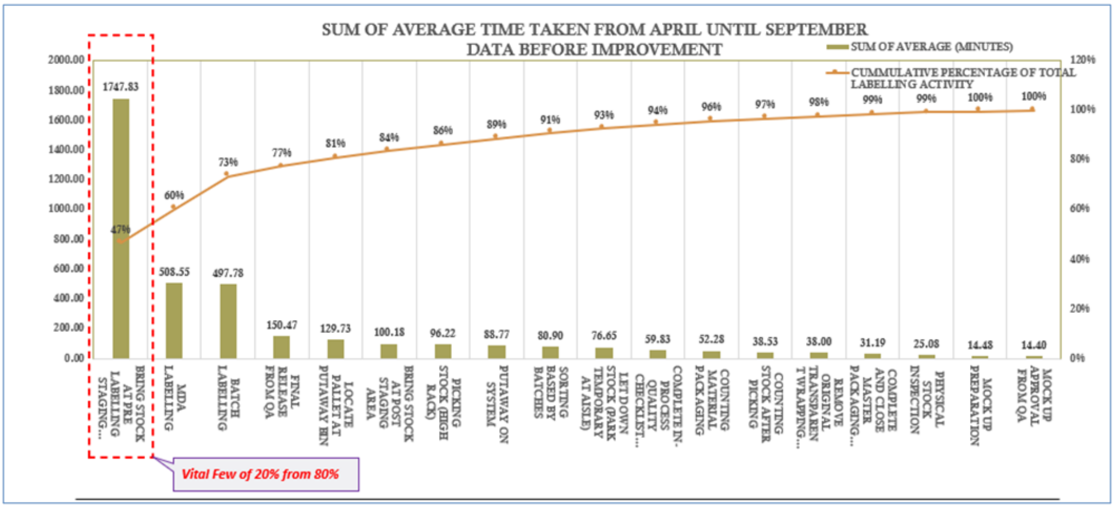

Figure 2: The plotted pareto chart based on summary in Table 5

Based on the Pareto analysis of the time spent on labelling activities, the results indicate that a small number of activities account for the majority of the total time. In particular, the *Pre-Labelling Staging Area* activity alone contributes a substantial 46.6% of the total labelling time, with an average of 358.33 minutes per unit in August and 530.00 minutes per unit in July. This far exceeds the 20% threshold suggested by the Pareto Principle. As *Pre-Labelling*

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Staging accounts for nearly half of the total time, it represents a critical target for improvement.

Focusing on optimising this process through workflow redesign, automation, or other efficiency measures could significantly reduce the overall labelling time. This finding supports Tanabe's (2018) interpretation of the Pareto Principle, which posits that a small number of causes (in this case, time-intensive activities) are responsible for a large proportion of the outcome (total time). Enhancing the efficiency of the pre-labelling staging process could therefore yield considerable time savings and operational improvements.

4.1 Fishbone diagram

The Fishbone Diagram (Figure 3) is employed in this study to systematically identify and analyse the root causes of delays in MDA sticker labelling processing time. By categorising potential contributing factors namely manpower, methods, materials, machines, measurement, and environment, it enables the identification of inefficiencies and informs targeted process improvements. This analytical tool also fosters team collaboration, strengthens problem-solving efforts, and supports data-driven strategies aimed at enhancing labelling efficiency and minimising delays.

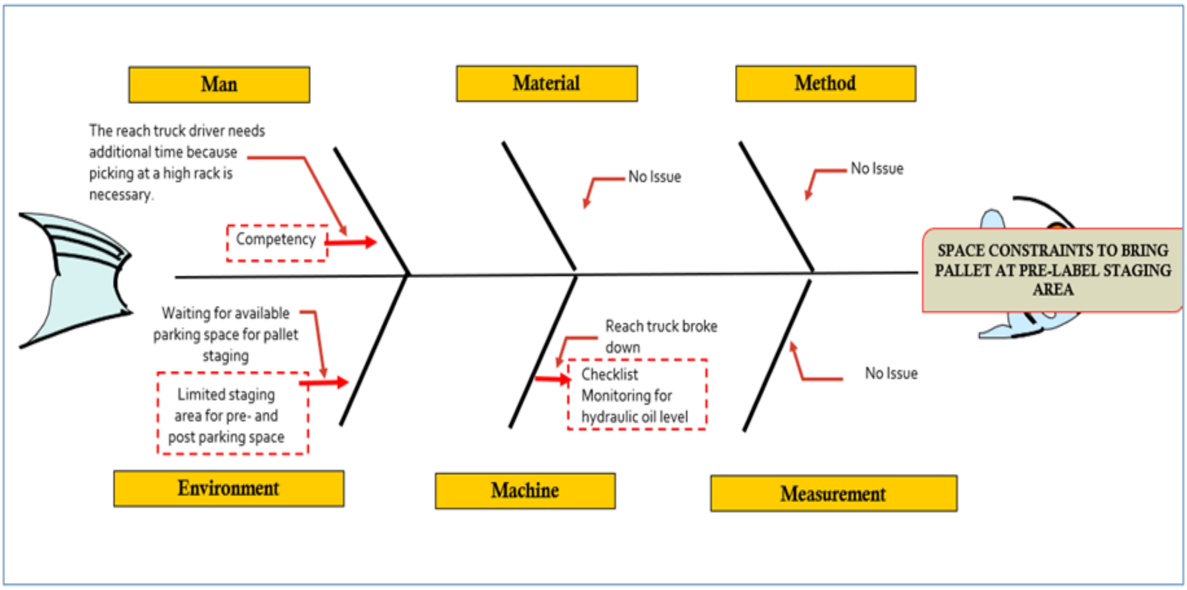

Figure 3: Fishbone diagram results identifying root cause factors and issues

Under the *Man* factor, the reach truck driver requires additional time to retrieve items from high racks, primarily due to competency issues. High-rack picking demands specific skills, including precision, spatial awareness, and careful manoeuvring at elevated heights. A lack of adequate training or experience can result in slower operations and reduced efficiency. Insufficient training may also lead to handling errors, operational delays, and lower overall productivity. Addressing this root cause through a structured and comprehensive training

Selangor Business Review

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

programme could enhance driver competency, leading to faster, more accurate, and safer operations (Wang et al., 2022).

Delays arising from the unavailability of parking spaces for pallet staging are attributed to the limited staging area for both pre- and post-parking activities (*Environment* factor). Inadequate or poorly designed staging areas create congestion and bottlenecks, disrupting the operational flow. When space is constrained, effective pallet management becomes challenging, resulting in prolonged waiting times and process delays. The root cause of this issue lies in the insufficient capacity and inefficient layout of the staging area. Optimising spatial utilisation and revising the layout and scheduling of the staging area could enhance material flow and significantly reduce delays (Nolz, 2021).

The reach truck breakdown was attributed to inadequate checklist monitoring of hydraulic oil levels. Hydraulic systems, which power many of a reach truck's key functions, require regular maintenance, including consistent monitoring of oil levels and cleanliness. Neglecting these checks can lead to malfunctions and breakdowns, resulting in costly operational delays and downtime. The root cause of such failures often lies in the absence of a systematic maintenance schedule for hydraulic oil inspection and replacement. Establishing structured maintenance protocols and ensuring their consistent implementation can substantially reduce the risk of breakdowns, thereby enhancing machinery reliability and operational continuity.

4.2 Five-Whys Analysis Results

In this study, Root Cause Analysis (RCA) (Figures 4 and 5) was employed to systematically identify and address the underlying factors contributing to delays in MDA sticker labelling processing time. The analysis focused on three key areas: operator competency, reach truck breakdowns, and limited staging space for pre-labelling activities.

4.2.1 Competency

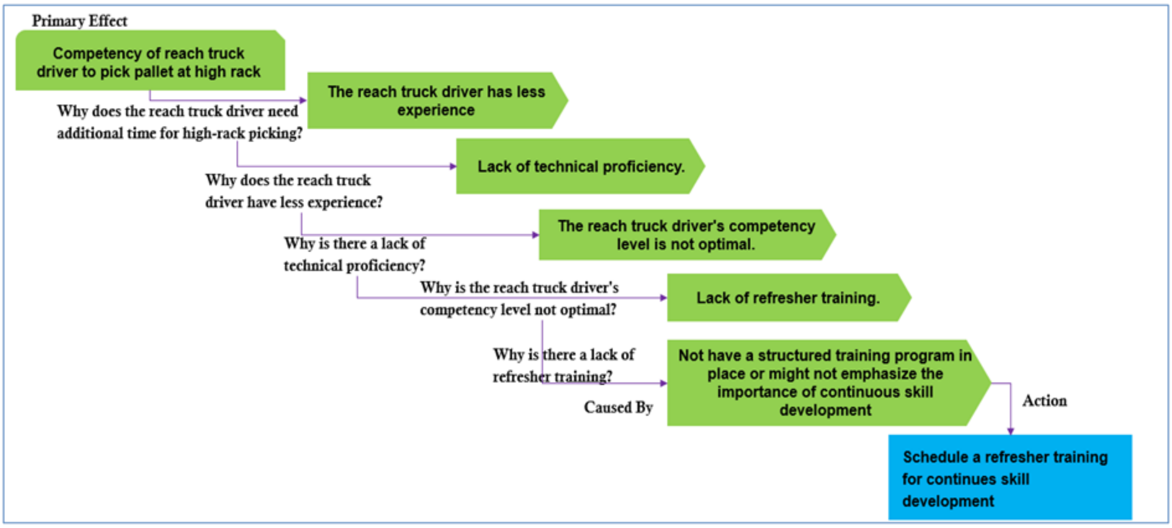

Figure 4: Root Cause Analysis of Reach Truck Driver's Competency in High-Rack Picking

Selangor Business Review

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

The reach truck driver's competency in picking pallets from high racks is limited by a lack of experience, resulting in additional time required for these tasks. This stems from insufficient technical proficiency, as the driver's competency level is not yet optimal. The root cause is the absence of refresher training, linked to either a lack of a structured training programme or inadequate emphasis on continuous skill development. The proposed action plan involves scheduling and implementing regular refresher training sessions to support ongoing skill enhancement, thereby improving the driver's competency and overall operational efficiency.

4.2.2 Reach Truck Breakdown

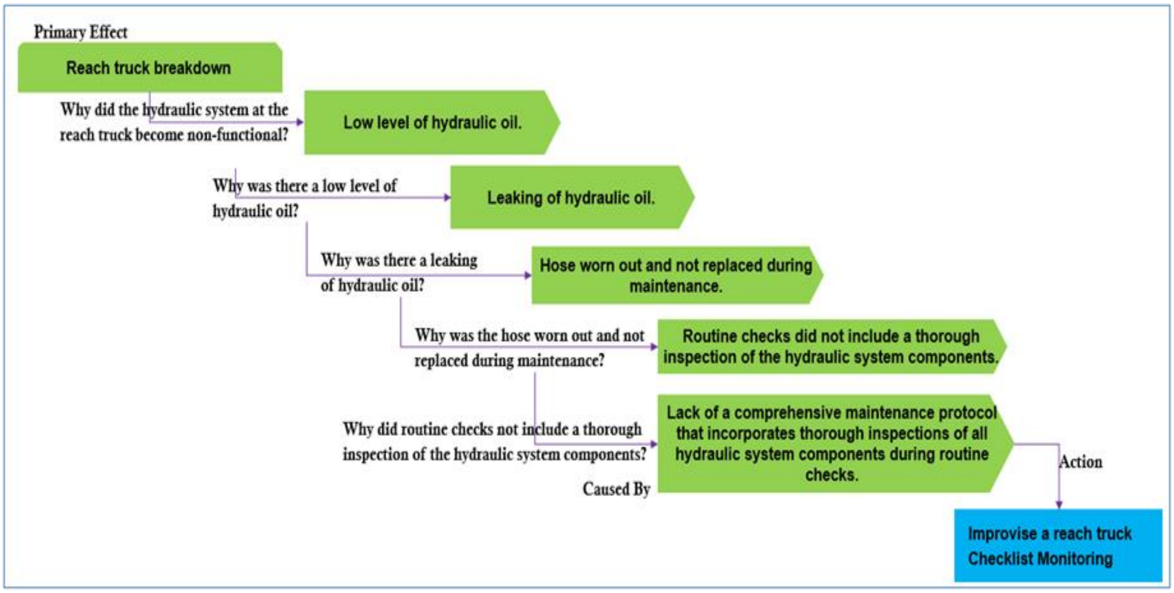

Figure 5: Root Cause Analysis of Reach Truck Hydraulic System Failure

The reach truck breakdown was caused by a non-functional hydraulic system, resulting from low hydraulic oil levels. The low oil level was traced to a hydraulic leak caused by a worn-out hose that had not been replaced during maintenance. The hose was overlooked because routine checks did not include a comprehensive inspection of all hydraulic system components. This lapse stemmed from the absence of a thorough maintenance protocol that ensures systematic inspection of the hydraulic system. The proposed action plan is to enhance the reach truck checklist monitoring system, enabling a detailed review of the hydraulic system during maintenance and preventing similar issues in the future.

4.2.3 Limited Staging Area for Pre-Labelling

Table 6 shows the details Five Whys analysis for congestion in the pre-labelling staging area causes delays in material flow.

Vol. 10, No. 2, p. 63-82
31 December 2025
(ISSN 2716-5876)

Table 6*:* The Five Whys Analysis for limited staging area for Pre-labelling

No	Why Question	Response
1	Why is there congestion in the pre-labelling staging area?	It can be due to temporary pallet parking is required while waiting for available space in the GMP area.
2	Why is temporary pallet parking required?	This is because the GMP area does not have enough space to accommodate all incoming pallets from production.
3	Why does the GMP area does not have enough pallet space?	Because the current layout is not optimised for efficient pallet storage and material flow.
4	Why is the layout not optimised for efficient pallet storage?	Because the existing layout was originally designed for lower production volumes and has not been updated to reflect the increased throughput and material handling requirements.
5	Why has the layout not been updated to reflect the increased production volume?	Because there was no prior capacity assessment or proactive layout planning to align space utilisation with production growth.

Based on the analysis, the root cause of the problem appears to be a lack of proactive layout optimisation and capacity planning in response to increased production volume, resulting in insufficient pallet space and congestion in the pre-labelling staging area. The constrained staging area has caused material flow disruptions and operational delays. Congestion arises because pallets must be temporarily parked while waiting for available space in the GMP area. This temporary parking is necessary due to the limited capacity of the GMP area, which in turn delays material movement.

The limited capacity of the GMP area is a consequence of an inefficient layout that was not designed to accommodate the increased volume of pallets required to meet production demands. Currently, the staging area can accommodate only four pallets at a time, which is inadequate for handling the growing production output. To address these issues, it is recommended to implement additional pallet staging and reconfigure the GMP layout to optimise pallet storage and material flow, thereby ensuring sufficient capacity to meet both current and future production requirements (Bhusari et al., 2024).

5. Conclusion

The Pareto analysis of labelling activities highlights key inefficiencies, with the *Pre-Labelling Staging Area* alone accounting for nearly half of the total time spent on labelling.

The primary cause of delays is an inadequate staging area, which results in congestion and operational bottlenecks. Optimising the staging layout and implementing structured scheduling can substantially improve efficiency. Additionally, the reach truck breakdown due to insufficient hydraulic oil monitoring underscores the need for a more rigorous maintenance protocol. Conducting regular maintenance checks, including detailed reviews of the hydraulic system, will help prevent future equipment failures and associated operational delays.

Moreover, inefficiencies in high-rack pallet picking emphasise the importance of continuous skill development. Implementing a structured refresher training programme for reach truck operators can enhance their competency, reduce delays, and improve overall workflow (Rahman, 2024; Srivastava et al., 2020). Addressing these root causes through targeted improvements in staging area management, equipment maintenance, and workforce training will contribute to a more efficient and streamlined labelling process, minimising downtime and enhancing productivity.

In conclusion, the analysis, from Pareto evaluation to current insights, has identified key operational challenges in the MDA labelling process, including reach truck driver competency, equipment breakdowns, and limited pre-labelling staging space. Addressing these challenges requires targeted interventions, such as refresher training, enhanced maintenance protocols, and layout optimisation to streamline pallet storage. Additionally, rigorous data validation is essential to ensure the accuracy, reliability, and relevance of collected information for informed decision-making. The implementation of these strategies is expected to improve both the efficiency and effectiveness of the MDA labelling workflow.

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