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WASTE ANALYSIS IN IN-PATIENT PHARMACEUTICAL DISPENSING SYSTEM BY LED GUIDE AND CONVEYOR BELT: AN APPLYING FROM DATA MINING TECHNIQUES

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ABSTRACT

Maharaj Nakhon Chiang Mai University Hospital implemented a daily dose medication distribution system with an automated conveyor for safe and effective medication management. However, delays during peak hours and medication errors have been observed. To identify waste in the medication distribution process and analyze frequently co-prescribed medications using data mining and association rule techniques to suggest improvements. A quantitative analysis of prescription data from April 1, 2022, to March 31, 2023, used process flow mapping and WASTE analysis. Data mining and association rule discovery in RapidMiner Studio analyzed co-prescribed medications, identifying associations among pairs, triples, and quadruples. Key statistical measures, including support, confidence, and lift, were calculated. The study analyzed seven zones of medication cabinets, focusing on a conveyor belt that completes a rotation in 84 seconds and has five ejection stations. On average, 1,853 medication orders are processed daily, with 1,391 entering through the guided cabinets and conveyor. The study used Frequent Pattern Growth to identify 151 co-prescription rules and found high error rates, mainly under-prescribed quantities, in Zone EL2 (injectable medicine). It also showed all eight wastes of DOWNTIME, including defects in error reports and overproduction from pre-packaging excess medications. By managing these issues, we can reduce waste linked to wait times and unnecessary movement by staff refilling medications in short supply. This enables staff to focus on other important tasks. Additionally, transportation and extra processing waste can be recognized through unnecessary ejections. The study identified eight types of waste in the pharmaceutical dispensing system and emphasized the need for continuous quality improvement based on lean principles to reduce waste and enhance efficiency. By optimizing storage, workflow, and staffing, as well as recognizing commonly co-prescribed medications, the process can be better organized. Using data analysis is essential for managing medications more effectively and minimizing medication errors.

Keywords: waste analysis, dispensing system, LED guide, frequent co-prescribed medications, hospital pharmacy

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Introduction

The hospital pharmacy department needs to make sure patients get their medications on time, but the many ways medications are transported create logistical challenges for a safe and effective medication management system.[1] The Hospital Pharmacists Association of Thailand supports daily dose distribution to reduce medication errors and the workload burden on nurses by using single-unit packaging, ready-to-use doses, and providing no more than a 24-hour supply of medications.[2] However, this system increases the demands on pharmacy departments by requiring them to prepare medications daily instead of in bulk for several days.

Based on routine records from Maharaj Nakhon Chiang Mai University Hospital, a 1,400-bed tertiary care facility, which we presented as part of a plenary session on "Automation, Technology, and Precision Medicines" at the 2023 Hospital Pharmacy Association of Thailand Annual Meeting on May 24, 2023, the hospital implemented a daily dose distribution system on April 1, 2022. This system serves 75 wards and includes automated dispensers, high-alert drug stations, manual stations, and semi-automated LED-guided systems with conveyor belts and RFID technology to ensure accurate medication management. In March 2023, the hospital reported an average of 6,102 daily dispensations, a 39% increase from the previous three-day model. The dispensations included 2,664 (43.66%) from the robot cabinet, 2,912 (47.72%) from LED cabinets, 168 (2.75%) from high-alert drug cabinets, and 358 (5.87%) manually. The system covers an operational area of 53.34 square meters, divided into seven zones (EL1, EL2, NL, SL, WL1, WL2, WL3) with capacities ranging from 144 to 192 items per zone. Each zone contains 3 to 4 guided medication cabinets, with the lower section measuring 0.60 × 1.04 × 0.76 meters and the upper section measuring 0.42 × 1.04 × 1.28 meters. A counterclockwise elliptical conveyor belt, which has a circumference of 17.37 meters and spans 9.6 square meters, completes one rotation in 84 seconds and includes five ejection stations with travel times of 22, 22, 9, 15, and 16 seconds. On average, 1,853 medication orders (ranging from 1,222 to 2,288) are processed daily, with 1,391 (925 to 1,741) entering through the guided cabinets and conveyor. These technologies have been proven to simplify medication management, reduce staff workload, and minimize medication errors, similar to improvements seen at Buriram Hospital.[3] The study of the inpatient medication dispensing system. The system uses RFID to match prescriptions with medication baskets, employing a one-prescription-per-basket approach. As baskets circulate, RFID readers detect incoming orders, ejecting baskets to the dispensing station in 4 seconds (See Figure 1).

Nonetheless, peak hours required an average of 648 items per hour, while the conveyor system managed only 428 items, causing delays in timely care. By lean principles, focused on maximizing value and minimizing waste, provide a framework for optimizing healthcare. Applied to inpatient pharmacy dosing, Lean streamlines medication processes. By reducing DOWNTIME wastes and promoting continuous improvement, it enhances patient safety (fewer errors), increases efficiency (better resource allocation), and improves staff satisfaction (streamlined workflows), ultimately improving medication use. This study aims to identify waste in the medication distribution process and analyze frequently co-prescribed medications using data mining and association rule techniques to suggest improvements that enhance workflow efficiency.

Ethics approval

The research was approved by the Chiang Mai University Faculty of Medicine Research Ethics Committee (Ethics approval number: EXEMPTION 0641/2567, issued on December 20, 2024).

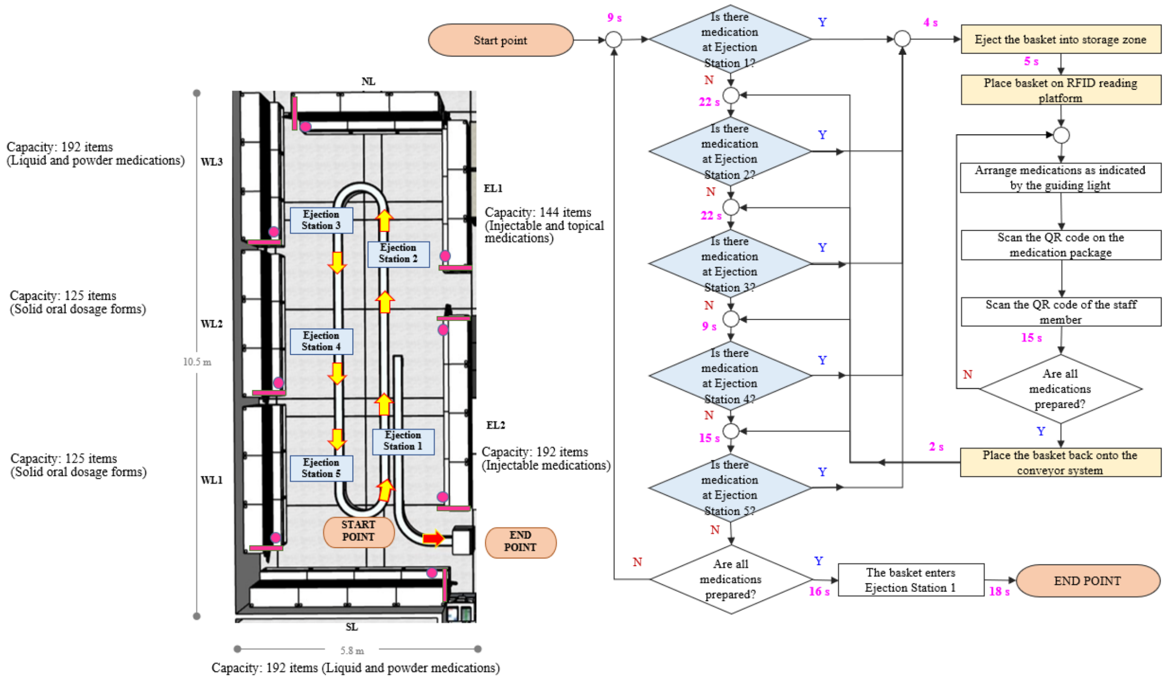

Figure 1 Pharmaceutical Dispensing System by LED Guide and Conveyor Belt Workflow

Methods

Design and study population

This study analyzes prescription data from the inpatient pharmacy at Maharaj Nakhon Chiang Mai University Hospital. It employs a quantitative and retrospective approach, covering the period from April 1, 2022, to March 31, 2023. The analysis comprises data from prescriptions for medications processed through the LED-guided cabinet and conveyor system, including tablets, injections, liquids, powders, and medications for external use. Prescriptions containing refrigerated medications, controlled substances, and chemotherapy agents were excluded, as were those generated during system disruptions, such as electrical failures or drug shortages, since these are not processed by this system. Additionally, the analysis incorporates data from medication error reports and observations of the medication preparation area, focusing on the eight types of waste identified during the medication distribution process.

Data collection/measurements

1. Analysis of waste in the LED-guided cabinets and conveyor belts

This study evaluates eight types of waste in the medication distribution system by focusing on key operational aspects through process flow mapping. The researcher assessed the layout and size of the medication storage area in the conveyor system and analyzed the dispensing process flow. Time was recorded at each basket elevation station, including conveyor rotation and travel time. Furthermore, records of medication errors and prepacked inventory were collected for further analysis, with details provided in Table 1.

2. Analysis of Frequently Co-Prescribed Medications

This approach identifies waste by analyzing the frequency and patterns of co-prescribed medications. Data mining and association rule discovery techniques are applied using RapidMiner Studio version 10.0. The results are presented as Itemset LHS (Left-Hand Side) => Itemset RHS (Right-Hand Side) to show which medications are frequently prescribed together. Using the frequent pattern growth (FP-Growth) technique, the analysis identifies associations among frequently co-prescribed pairs, triples, and quadruples of medications

Table 1 Summary of data collection methods and evaluation criteria for analyzing losses

Variable	Data Collection Method	Data Collected	Evaluation Criteria
Defect	Medication error reports from the automated system	Number, type, and medications associated with errors by station	• Percentage of errors per dispensing station • Proportion of errors in frequently co-prescribed pairs • Top 10 error locations
Overproduction	Observation of the preparation area	Quantity of pre-packed medications, preparation time	• Ratio of pre-packed to daily dispensing • Percentage of errors from pre- packed medications
Waiting	Automated system data	Time spent dispensing medications	Change in average dispensing time when medications are repositioned closer
Non-utilized talent	preparation area	Observation of the Staff count, age, tenure	• Ratio of staff before and after repositioning medications • Average staff tenure before and after repositioning
Transportation	Automated system data	Maximum time taken for tote ejection across stations	Percentage of totes making multiple loops or waiting
Inventory	Observation of the preparation area	Frequency of replenishment per day	• Percentage needing replenishment > once daily • Items dispensed ≤ once a month for potential removal
Motion	Observation of the preparation area	Movement frequency and retrieval time for multiple items	• Average time for dispensing separated vs. adjacent items • Percentage of frequently co-prescribed pairs stored apart
Extra Processing	Automated system data	Frequency of totes ejected into dispensing stations	Percentage change in dispensing time when reducing ejection points

Results

The analysis reviewed 677,006 prescriptions and 2,119,264 dispensed items. Of these, 507,660 prescriptions were processed using the LED-guided cabinet and conveyor system, resulting in 970,437 items. For prescriptions with two or more items, there were 215,034 prescriptions, totaling 677,811 dispensed items. The FP-Growth technique identified association rules, resulting in 53, 76, and 22 rules for co-prescribed medication pairs of 2, 3, and 4 items, respectively, with minimum support and confidence thresholds set at 0.001 and 0.6. Only 6 of the 30 most common co-prescribed combinations can be prepared with a single dispensing tip.

This evaluation of waste in the system reveals the following categories:

Defect: Zone EL2 (Injection medicines) had the highest number of errors, totaling 739 reports. The most common error across all zones was "quantity less than prescribed," occurring 1,072 times. Among frequently co-prescribed medications, magnesium injection 50% 2 ml had the highest number of errors, recorded 62 times. For all injection preparations in the EL2 zone, implement a mandatory, documented double-check process (e.g., electronic sign-off or physical sticker) prior to dispensing.

Overproduction: Seventeen pre-packaged items were prepared in the conveyor belt area, taking a total of 135 minutes daily. Eight medications had lower dispensing rates compared to the inventory, while the most dispensed medication, ceftriaxone injection 1 gm (2 ampules per pack), frequently faced stock shortages (See Figure 3). Stop pre-packaging the eight low-volume medications and reallocate the 135 minutes/day and space to ceftriaxone injection to eliminate shortages and improve workflow stability, which will help reduce dispensing errors.

Waiting: The average time difference between the first and last medication in a two-item prescription stored in the same zone was 0:09 minutes, increasing to 4:06 minutes when stored in different zones. For three-item prescriptions, the average was 0:17 minutes in the same zone and 5:19 minutes across different zones, while for four-item prescriptions, it was 0:22 minutes in the same zone and 6:39 minutes when stored differently (see Table 2). Reorganize the storage layout to group frequently co-prescribed items, directly solving the split-zone storage problem and reducing waiting time for multi-item scripts.

Non-utilized Talent: Seven pharmacy assistants work with the LED-guided cabinets and conveyor system in the same roles during and after regular hours. Analyzing the motion data, relocating frequently co-prescribed medications closer together could reduce their moving time and improve their focus when preparing medications. Rotate personnel from optimized, dual-staffed zones (like EL2) into critical tasks to leverage saved time, maximizing both staff utilization and skill development.

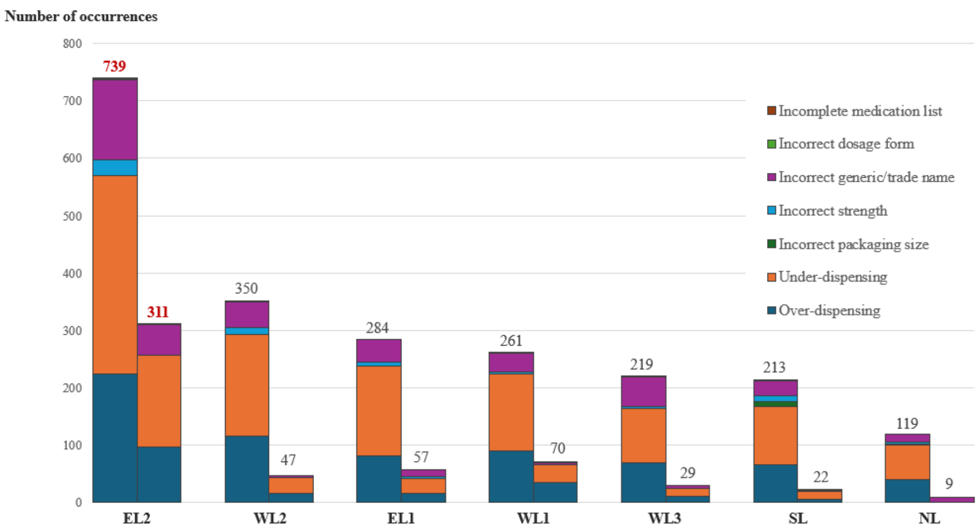

Figure 2 A stacked bar chart displaying dispensing discrepancies. The left side shows total discrepancies, while the right-side highlights discrepancies from the top 10 frequently co-prescribed medication pairs of 2, 3, and 4 items, categorized by medication zones.

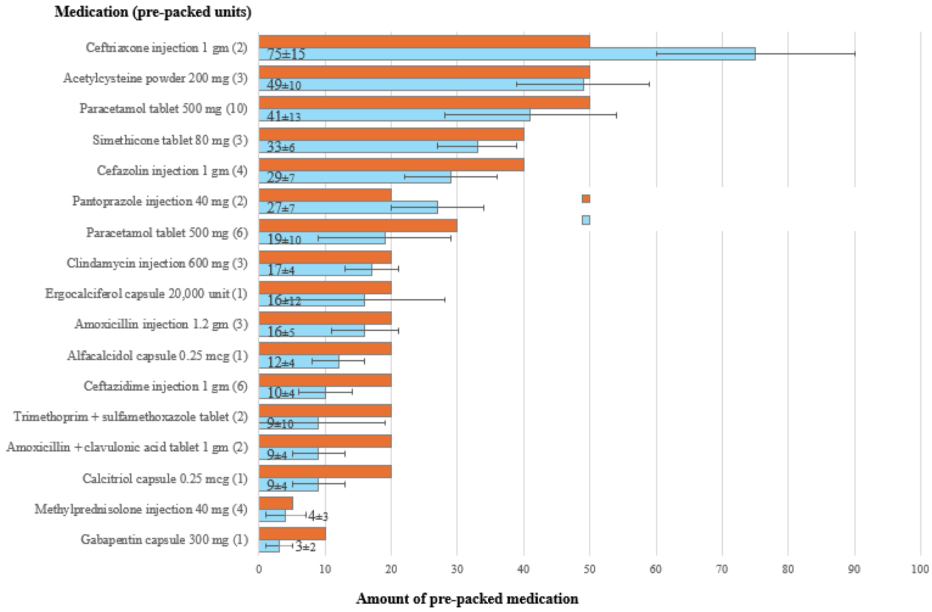

Figure 3 Pre-packed medication, quantity of daily pre-packed unit and dispensing volume

Table 2 Average Time Difference Between Each Medication Item Dispensing

Number of Medications in Prescription and Storage Zone	Average Time (minutes)	Maximum Time (minutes)	Minimum Time (minutes)
2 medications, same zone	0:09	22:46	0:01
2 medications, different zones	4:06	29:56	0:01
3 medications, same zone	0:17	11:15	0:01
3 medications, different zones	5:19	29:57	0:04
4 medications, same zone	0:22	5:22	0:01
4 medications, different zones	6:39	29:57	0:05

Transportation: The time difference between the first and last medication dispensed from the system, categorized by the number of stations where baskets were ejected. The average time differences (max-min) were 1:33 minutes for 1 station, 3:53 minutes for 2 stations, 6:41 minutes for 3 stations, 10:03 minutes for 4 stations, and 13:18 minutes for 5 stations. Redesign dispensing logic and audit settings to limit basket ejection to two per order as a short-term solution.

Inventory: Among the 986 medications in the dispensing system, the paracetamol tablet 500 mg had the highest daily dispensing rate of 1,472 tablets, which means it needs to be restocked more than once a day. Eighteen injectable medications, like ceftriaxone injection 1 gm and cefazolin injection 1 gm, also need frequent restocking. On the other hand, 47 medications (4.77%) were dispensed less than once a month, leading to excess inventory. Adjust stock levels for high-use drugs and remove or relocate low-demand items to optimize inventory efficiency.

Motion: The average time spent dispensing medications based on their location showed that two items stored close together took an average of 24±6 seconds. When items were stored farther apart, the average time increased to 28±9 seconds. Storing frequently co-prescribed items farther apart increased the average dispensing time for two items from 24 seconds to 28 seconds. For three items stored closely, the average time was 35±7 seconds, while greater distances raised the average to 41±15 seconds. Among frequently prescribed pairs, 16 out of 53 pairs were in the same zone but located farther apart, while 9 pairs were stored closer together. For groups of three items, 14 out of 76 were in the same zone but spaced farther apart, with only 1 group stored closely together. Reorganize storage to place frequently co-dispensed items closer together, reducing travel time and improving dispensing efficiency.

Extra processing: Baskets were ejected 437,008 times for prescriptions containing two or more items. For frequently co-prescribed pairs, 25 pairs had 1 ejection, and 28 pairs had 2 ejections. Three-item groups had 16 with 1 ejection, 38 with 2, and 22 with 3. For four-item groups, the ejections were: 1 for 1 ejection, 8 for 2, 11 for 3, and 2 for 4. To reduce waste, especially for co-prescribed groups, adjust dispensing logic to eliminate unnecessary 11-second basket ejections. Total ejections were 65,647 for two-item groups, 73,037 for three-item groups, and 17,950 for four-item groups. If each prescription resulted in one ejection, the new totals would be 45,591, 36,445, and 6,832. The conveyor belt takes 84 seconds for a full rotation, with travel times between stations ranging from 9 to 22 seconds. Average picking times are 15 seconds for one item, 26 seconds for two items, and 38 seconds for three items in the same zone. Movement time while retrieving medication is about 6 seconds per meter. There are 186 items in SL, 130 in EL1, 143 in EL2, 140 in NL, and 124 to 126 in WL zones. A total of 2,185 discrepancies were reported in the medication dispensing process. This study established waste reduction potential by analyzing the processing of frequently co-prescribed medications (e.g., paracetamol basket elevation). While data mining is vital for recognizing all co-prescriptions, further investigation must stratify this data by patient ward, disease, and demographics to achieve clinically actionable insights. Redesign basket ejection logic to consolidate multi-item prescriptions into fewer ejections and optimize item placement by zone to minimize conveyor travel and picking time, reducing processing delays and discrepancies.

Discussion

An analysis of defects in the dispensing system by LED guide and conveyor belt revealed that the highest error rate was due to dispensing the wrong quantity, followed by dispensing the wrong type. In contrast, a study at Srinakarin Hospital found that the most common error in LED cabinets was dispensing the wrong type, followed by incorrect quantity.[4] Observations indicated that the primary cause of medication errors was staff haste, leading to non-adherence to procedures. Some staff skipped barcode scanning or scanning without retrieving the medication to save time. Additionally, the open design of the LED cabinet increased the risk of picking the wrong medication due to misidentification of items near the flashing light. The investigations showed that dispensing times varied depending on where medications were stored. Prescriptions kept in the same zone were retrieved more quickly than those stored in different zones. These findings support lean principles[5], highlighting that improving storage locations is key to enhancing operational efficiency by reducing waiting times and unnecessary movement, which helps staff follow procedures better.[6]

Overproduction waste in pre-packaging identified 17 medications with different quantities. Daily dispensing data showed discrepancies between pre-pack levels and needs, indicating overproduction for 8 medications. Ceftriaxone, despite being pre-packed in the highest quantities, was still not enough for daily use. Pre-packaging took 135 minutes each day, increasing the workload for pharmacy assistants. Optimizing storage can reduce retrieval times[7] and costs[8], while improving inventory processes can save time and lower error rates[9], with 105 errors linked to pre-packed medications. Implementing lean strategies to reduce overproduction can enhance patient care and improve the efficiency of pre-packed production.[5] For example, a data mining study found that the most common combination of medications was metronidazole injection and ceftriaxone injection, which are often used for patients with intra-abdominal infections who need broad-spectrum antibiotics.[10] The study also identified a frequently co-prescribed combination of three medications based on support value. This combination, which makes up 1.60% of all prescriptions, includes pantoprazole injection 40 mg, metronidazole injection of 500 mg, and ceftriaxone injection 1 gm, with a confidence level of 84.74%. Cefazolin is recommended for surgical prophylaxis at a dose of 2 g, with a redosing interval of 4 hours.[11] The medication is available in pre-packed 4 ampules, which often leads to insufficient availability due to daily demand. This situation affects the stock of pantoprazole in the frequently co-prescribed combination, as shown in Figure 3.

Utilizing dispensing frequency data is key to optimizing pharmaceutical supply chains, reducing excess inventory, and enhancing storage efficiency.[5] The study identified inventory waste linked to dispensing volume and restocking frequency. For further workflow improvement, high-demand medications require frequent restocking, indicating a need for more storage space, while low-frequency medications can be relocated to a reserved area to optimize space for high-demand items.[12]

In the optimized pharmacy system, having seven assistants shows a waste of talent. By moving frequently prescribed medications to busy areas, especially in zone EL2, we can make work easier and reduce the number of staff needed, possibly cutting down from two assistants to one. This change would allow staff to rotate into important roles, such as managing robot and HAD cabinets, improving efficiency. While the study does not confirm a reduction in staff, using daily rotation schedules can increase motivation and performance by reducing repetitive task fatigue.[5,13,14]

The analysis of transportation waste in the conveyor system showed that retrieval times increased with more ejection stations, from 1:33 minutes for one station to 13:18 minutes for five. This points to inefficiencies in the process that affects dispensing. Improving medication positioning and optimizing the ejection system can reduce idle waiting times, in line with lean management principles to eliminate non-value-adding activities.[15] For example, two essential parenteral nutrition components for total parenteral nutrition in critically ill patients—a lipid emulsion (10 ml) and a preparation of essential amino acids, vitamins, and minerals (10 ml)[16] —were prescribed together in 1.18% of prescriptions. However, they are located in different zones, as shown in Table 2. An effective warehouse layout and streamlined processes are necessary to address this waste and resolve bottlenecks, which will enhance efficiency in the transportation system.[17] Nevertheless, real-time monitoring of basket rotation and waiting times will help refine processes and discover further inefficiencies.

This study demonstrates the potential to eliminate waste from unnecessary processing by collecting data on how often baskets are elevated to retrieve paracetamol, which is frequently co-prescribed with other medications. For example, oral antibiotics such as cefixime 100 mg and cephalexin 500 mg are often prescribed with paracetamol for treating respiratory and urinary tract infections.[18] Additionally, 0.53% of prescriptions combine cefazolin 1 gm and ondansetron 4 mg with paracetamol for managing anesthesia-related nausea[19], with a confidence level of 63.36%. The study also found that 0.47% of prescriptions pair prednisolone eye drops 5 ml and dexamethasone/neomycin/polymyxin B ointment with paracetamol for post-operative eye inflammation.[20] By placing paracetamol in multiple zones where these co-prescriptions occur, we could reduce the extra processing involved in retrieving it.

In summary, the study of the pharmaceutical dispensing system using LED guide and conveyor belt identified eight types of waste in the workflow, leading to significant mistakes and inefficiencies. This emphasizes the importance of following lean principles to improve process effectiveness by concentrating on reducing waste. Recognizing co-prescriptions through data mining is vital for detecting waste and identifying areas for enhancement. For further investigation, subsequent studies should stratify co-prescription data according to patient ward, disease, and demographic variables, transitioning from generalized patterns to clinically actionable insights.

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Table Supplementary: Top 10 Association Rules for Co-Prescribed Medications (2, 3, and 4 Items)

Number of items in Co-Prescribed Medications	Premises	No. of dispensing tip	Conclusion	No. of dispensing tip	Support	Confidence	Lift
2	Mepagyl Inj 500 mg/ 100 ml	1	Cef-3 IV 1 gm	1	0.0424	0.7267	6.1032
2	Vitalipid N *ADULT* 10 ml (dispensing tip no.2)		Addamel-N IV 10 ml (dispensing tip no.1)		0.0118	0.8955	54.3181
2	Pred Forte Eye Drops 5 ml (dispensing tip no.3)		Beramol Tab 500 mg (dispensing tip no.5)		0.0102	0.8363	6.0183
2	FerLi - 6 Tab (dispensing tip no.5)		Beramol Tab 500 mg (dispensing tip no.5)		0.0100	0.6790	4.8864
2	Soluvit N Inj (dispensing tip no.1)		Addamel-N IV 10 ml (dispensing tip no.1)		0.0093	0.8189	49.6745
2	Amanda Cap 50 mg (dispensing tip no.4)		Beramol Tab 500 mg (dispensing tip no.5)		0.0088	0.6281	4.5200
2	Maxitrol Eye Oint 3.5 g (dispensing tip no.3)		Beramol Tab 500 mg (dispensing tip no.5)		0.0058	0.8115	5.8404
2	Cefspan Cap 100 mg (dispensing tip no.3)		Beramol Tab 500 mg (dispensing tip no.5)		0.0054	0.7010	5.0447
2	CEPhalex Cap 500 mg (dispensing tip no.5)		Beramol Tab 500 mg (dispensing tip no.5)		0.0053	0.7111	5.1176
2	Maxitrol Eye Oint 3.5 g (dispensing tip no.3)		Pred Forte Eye Drops 5 ml (dispensing tip no.3)		0.0053	0.7383	60.4600
3	Pantoval Inj 40 mg (dispensing tip no.1), Mepagyl Inj 500 mg/ 100 ml (dispensing tip no.1)		Cef-3 IV 1 gm (dispensing tip no.1)		0.0160	0.8474	7.1166
3	Vitalipid N *ADULT* 10 ml (dispensing tip no.2), Soluvit N Inj (dispensing tip no.1)		Addamel-N IV 10 ml (dispensing tip no.1)		0.0060	0.9005	54.6218
3	CefaBEN Inj 1 gm (dispensing tip no.1), Onsia *Inj 4 mg (dispensing tip no. 2)		Beramol Tab 500 mg (dispensing tip no.5)		0.0053	0.6336	4.5601

Table Supplementary: Top 10 Association Rules for Co-Prescribed Medications (2, 3, and 4 Items) (continue)

Number of items in Co-Prescribed Medications	Premises	No. of dispensing tip	Conclusion	No. of dispensing tip	Support	Confidence	Lift
3	Miracid (omeprazole) Cap 20 mg (dispensing tip no.4), Aspent-M Tab 81 mg (dispensing tip no.5)		XARAtor Tab *40 mg* (dispensing tip no.3)		0.0048	0.7515	45.2501
3	Pred Forte Eye Drops 5 ml (dispensing tip no.3), Maxitrol Eye Oint 3.5 g (dispensing tip no.3)		Beramol Tab 500 mg (dispensing tip no.5)		0.0047	0.8789	6.3256
3	Pred Forte Eye Drops 5 ml (dispensing tip no.3), Cravit Eye Drops 0.5% 5 ml (dispensing tip no.3)		Beramol Tab 500 mg (dispensing tip no.5)		0.0043	0.8847	6.3667
3	MAGNESIUM Inj 50% 2 ml (1g/2ml) *HAD* (dispensing tip no.1), Onsia *INJ *8 MG* (dispensing tip no.1)		Lodexa-5 Inj. 5mg (dispensing tip no.1)		0.0040	0.7839	16.7427
3	Milk of Magnesia 240 ml (dispensing tip no.5), FerLi - 6 Tab (dispensing tip no.5)		Beramol Tab 500 mg (dispensing tip no.5)		0.0040	0.9409	6.7716
3	Pred Forte Eye Drops 5 ml (dispensing tip no.3), ToBrex Eye Drops 5 ml (dispensing tip no.2)		Beramol Tab 500 mg (dispensing tip no.5)		0.0039	0.8720	6.2755
3	Pantoval Inj 40 mg (dispensing tip no.1), Vitamin K1 10 mg/ml (dispensing tip no.1)		Transamin Inj 250 mg/5 ml (dispensing tip no.2)		0.0037	0.6204	22.5528

Table Supplementary: Top 10 Association Rules for Co-Prescribed Medications (2, 3, and 4 Items) (continue)

Number of items in Co-Prescribed Medications	Premises	No. of dispensing tip	Conclusion	No. of dispensing tip	Support	Confidence	Lift
4	Vitalipid N *ADULT* 10 ml (dispensing tip no.2), Vitamin C *INJ 500 mg/ 2 ml (dispensing tip no.1), Vitamin B-complex Inj 1 ml (dispensing tip no.1)		Addamel-N IV 10 ml (dispensing tip no.1)		0.0027	0.9354	56.7384
4	Miracid (omeprazole) Cap 20 mg (dispensing tip no.4), Senolax Tab (dispensing tip no.3), Aspent-M Tab 81 mg (dispensing tip no.5)		XARAtor Tab *40 mg* (dispensing tip no.3)		0.0026	0.8803	53.0095
4	Pred Forte Eye Drops 5 ml (dispensing tip no.3), Maxitrol Eye Oint 3.5 g (dispensing tip no. 3), ToBrex Eye Drops 5 ml (dispensing tip no.2)		Beramol Tab 500 mg (dispensing tip no.5)		0.0023	0.8946	6.4385
4	Senolax Tab (dispensing tip no.3), Anta Tab 0.5 mg (dispensing tip no.5), Aspent-M Tab 81 mg (dispensing tip no.5)		XARAtor Tab *40 mg* (dispensing tip no.3)		0.0018	0.9265	55.7930
4	Senolax Tab (dispensing tip no.3), Anta Tab 0.5 mg (dispensing tip no.5), XARAtor Tab *40 mg* (dispensing tip no.3)		Miracid (omeprazole) Cap 20 mg (dispensing tip no.4)		0.0018	0.8351	23.6729

Table Supplementary: Top 10 Association Rules for Co-Prescribed Medications (2, 3, and 4 Items) (continue)

Number of items in Co-Prescribed Medications	Premises	No. of dispensing tip	Conclusion	No. of dispensing tip	Support	Confidence	Lift
4	Miracid (omeprazole) Cap 20 mg (dispensing tip no.4), Anta Tab 0.5 mg (dispensing tip no.5), Aspent-M Tab 81 mg (dispensing tip no.5)		XARAtor Tab *40 mg* (dispensing tip no.3)		0.0017	0.8940	53.8321
4	Miracid (omeprazole) Cap 20 mg (dispensing tip no.4), Anta Tab 0.5 mg (dispensing tip no. 5), Aspent-M Tab 81 mg (dispensing tip no. 5)		Senolax Tab (dispensing tip no.3)		0.0016	0.8530	32.2252
4	Beramol Tab 500 mg (dispensing tip no.5), Maxitrol Eye Oint 3.5 g (dispensing tip no.3), Cravit Eye Drops 0.5% 5 ml (dispensing tip no.3)		Pred Forte Eye Drops 5 ml (dispensing tip no.3)		0.0015	0.9034	73.9767
4	Miracid (omeprazole) Cap 20 mg (dispensing tip no.4), XARAtor Tab *40 mg* (dispensing tip no.3), BriLINta Tab *90 mg* (dispensing tip no.5)		Aspent-M Tab 81 mg (dispensing tip no.5)		0.0013	0.9965	83.1867
4	Lodexa-5 Inj. 5mg (dispensing tip no.1), Onsia *INJ *8 MG* (dispensing tip no.1), KCL Inj 20 meq *HAD* (20 mEq/10 ml) (dispensing tip no.1)		MAGNESIUM Inj 50% 2 ml (1g/2ml) *HAD* (dispensing tip no.1)		0.0012	0.9537	17.4303