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USAID GLOBAL HEALTH SUPPLY CHAIN PROGRAM
Procurement and Supply Management

WINNING THE LOGISTICS GAME

A guide for health logisticians to transform their operations and swiftly deliver medicines and supplies to their communities

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The USAID Global Health Supply Chain Program-Procurement and Supply Management (GHSC-PSM) project is funded under USAID Contract No. AID-OAA-I-15-0004. GHSC-PSM connects technical solutions and proven commercial processes to promote efficient and cost-effective health supply chains worldwide. Our goal is to ensure uninterrupted supplies of health commodities to save lives and create a healthier future for all. The project purchases and delivers health commodities, offers comprehensive technical assistance to strengthen national supply chain systems, and provides global supply chain leadership.

GHSC-PSM is implemented by Chemonics International, in collaboration with Arbola Inc., Axios International Inc., IDA Foundation, IBM, IntraHealth International, Kuehne + Nagel Inc., McKinsey & Company, Panagora Group, Population Services International, SGS Nederland B.V., and University Research Co., LLC. To learn more, visit ghsupplychain.org

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Introducing: The Winning the Logistics Game Guide

Public health logisticians provide life-saving medicines at the right time, place, and quantity, ensuring the continued health of their fellow citizens. They also manage challenges every day, such as the lack of coordination between procurement implementing partners, infrequent deliveries in bulk to their warehouses, and even less frequent deliveries to service delivery points (SDPs), all while large volumes of stock arrive, requiring space at the warehouse. These obstacles can result in supply chain cycle delays, high costs, product damage and expiration, and clinic stockouts.

One public health system set out to get ahead of these obstacles. The Ethiopian Pharmaceutical Supply Agency (EPSA), in collaboration with the USAID Global Health Supply Chain Program-Procurement and Supply Management (GHSC-PSM) project and John Snow, Inc. (JSI)/AIDS Free, piloted a process improvement program called the **Center of Excellence** (COE), at a major EPSA warehouse in Adama, Ethiopia. The COE improved warehouse operations via foundational layout and design, key performance indicators (KPIs), and product flow using best commercial warehousing practices. The activity was so impactful that GHSC-PSM in Ethiopia and JSI/AIDS Free implemented the methodology across seven additional EPSA warehouse hubs.

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This guide, Winning the Logistics Game, builds on the foundations of the COE piloted with EPSA, helping readers to apply COE principles and operationalize its tenets. It introduces key concepts like inventory turnover; using throughput to gauge the ability to coordinate activities; and receiving best practices. With these concepts in place, the guide provides tools and approaches for achieving excellence—by using the plan-do-check-act cycle (PDCA) and a daily planner tool to eliminate as much work in progress (WIP) as possible. We advise readers to review the report on Ethiopia's COE implementation in conjunction with this guide to provide more context and lessons learned.

Center of Excellence Key Principles

These steps were used in Ethiopia to improve warehouse performance and efficiency:

1. Inventory analysis, including Activity Based Costing (ABC) and Fast-Moving, Slow-Moving, and Non-Moving inventory analysis (FSN)
2. Storage method and zoning determination and reconciliation
   - Product flow
   - Fixed Pick: phase creation
   - Zoning of commodities based on inventory analysis
   - Actual available space reconciliation with product flow
3. Product relocation
   - Product segregation and palletization
   - Pallet labeling and wrapping
   - Moving to zones
   - Updating product location in commodity and logistics information system

Find complete documentation of the COE pilot in Ethiopia here.

Why Read this Guide?

It can help you transition from "warehouse" to "distribution center"

The function of a ***warehouse*** is to provide maximized long-term storage space, but a ***distribution center*** optimizes the coordination of all activities. This optimization should create an unimpeded and rapid product flow through the facility. This guide will help you to survive and thrive through the inevitable transition from warehouse to distribution center operations. It teaches logisticians how to increase focus on efficiency and maximize the value of the funds allocated to procuring pharmaceuticals. Mastering the methodology herein will allow you to gain control over the flow of products coming in and going out, determine the outcomes of your facility's activities, and reduce outside performance influences—such as upstream financial decisions like unpredictable bulk orders.

> *"If you can't measure it, you can't manage it."*
>
> - Peter Drucker, business management expert

This guide is based on operational practices from commercial and private sector distribution centers. Commercial supply chains continuously strive to do things better, smarter, cheaper, and, most importantly, faster. This guide will assist public health logisticians in preparing for the inevitably fast pace of the public health supply chain, improving your ability to orchestrate activities and serve customers more efficiently.

Understanding logistics vs. supply chain

> *"Imagine a game of football or soccer: there is the infrastructure, the stadium, the bleachers, the lights. They represent the supply chain, the assets used to move goods and services from one point to another. They are boats, planes, trains, trucks, motorcycles, and even drones. All the things that let the game take place. Logistics is what is being played on the field."*
>
> - E.H. Frazelle, PhD

It is this game of logistics – and how to "win" it – that will be addressed in this field guide.

This guide will not only provide an understanding of how to run a world-class distribution center, but also emphasizes that medical commodities—essential medicines and long-lasting insecticide-treated nets (LLINs), for example—have no value in the hands of the manufacturer, on the boat, train, plane, truck or motorcycle, at the warehouse, or even the clinic. The only place that those medicines or nets have value is **in the hands of the patient**. This guide will give tips and tools to deliver critical commodities efficiently and accurately to patients in need.

Who should use this guide?

This guide is targeted to public health logisticians, or integrated commercial logistics (ICL) warehouse operators, and other stakeholders in this realm, to help them understand and effectively manage the factors affecting their supply chains.

Key Definitions

First-expired, first-out (FEFO) principle: The goods whose shelf life expires first are processed also first.

Hit density: The amount of picking activity in each warehouse area versus the amount of travel time required. High hit density is more productive than lower hit density. A "hit" is a stop or a location where product is picked/selected from for outbound orders. More product selected with less travel is the desired outcome.

Inventory Turnover Ratio (ITR) or Unit Turn Ratio (UTR): The number of times a warehouse has shipped and replenished its inventory over a specific period. Fast-moving items are allocated preferential locations. Placing products with a high turnover rate close to the storage and retrieval area keeps average travel distances in the warehouse short and enables quick access.

Interleaving: A commercial warehouse operator may assign more than one type of task to one individual. For example, a forklift operator can and should do inbound put-aways into the rack and also do replenishments to a fixed bin pick slot, and may even bring empty pallets to the receiving dock for reuse. This movement between activities as time allows is known as interleaving.

Little's Law/Queuing Theory: "The average number of customers in a stationary system is equal to the long-term average effective arrival rate, multiplied by the average time that a customer spends in the system." In simple terms, this means that the more customers in the queue, the longer the average waiting time for each customer. This can be seen when there are more pickers/selectors in an aisle picking than the space will allow. Adding more pickers/selectors to try and achieve more picks completed only serves to slow all pickers/selectors down due to the congestion created.

Maximum warehouse utilization: Warehouse or warehouse capacity utilization measures how effectively you use the total area. Companies that can successfully utilize their warehouse space can reduce their storage costs. However, you should never increase the capacity above 85-90 percent used capacity. Some empty locations are required in anticipation of inbound receiving.

Pick slot or fixed bin: To optimize the picking/selecting process, product should be assigned to a specific location and that location consistently used—convenient to the ground level—to pick or select from. The product is replenished to this assigned pick slot/fixed bin to ensure proper expiry rotation.

The Pareto Rule: The 80-20 rule, also known as the Pareto Principle, asserts that 80 percent of outcomes (or outputs) result from 20 percent of all causes (or inputs) for any given event. In business, a goal of the 80-20 rule is to identify potentially productive inputs and make them the priority.

Theory of Constraints (TOC): Every process is limited by some kind of constraint (think "a chain is only as strong as its weakest link"). TOC is about tuning an entire supply chain to run at the same pace as the slowest step in the process.

Warehouse Management System: A warehouse management system is a set of policies and processes intended to organize the work of a warehouse or distribution center and ensure that such a facility can operate efficiently and meet its objectives.

Daily Planner: An Excel-based planning tool to anticipate the workload for each activity within a given shift.

Work in progress (WIP): All ongoing work at any given moment in the warehouse. WIP decreases the flow of people and goods through the supply chain by creating unnecessary work buffers between activities, often getting in each other's way.

Labor report: An Excel-based tool designed for your distribution center. It uses your daily throughput performance for a given month and compares it to last month's performance, helping to understand the seasonality of your business and long-term staffing/hiring trends.

Activity-based costing (ABC): ABC first assesses the wage costs for direct labor associated with warehousing and distribution activities and then allocates indirect costs, such as non-direct wage costs, overhead costs (e.g., building maintenance and utilities), equipment purchases and maintenance, and fuel costs to these labor activities.

Activity-based management (ABM): Activity-based management (ABM) is cost management based on the information that comes from ABC. ABM seeks improve efficiency and reduce cost and may include implementing things such as a value chain study, reengineering, or investigation of customer/product profitability.

Plan-do-check-act (PDCA): The PDCA cycle is a continuous loop of planning, doing, checking (or studying), and acting. It provides a simple and effective approach to solving problems and managing change. The model is useful for testing improvement measures on a small scale before updating procedures and working practices.

Throughput: The number of units produced per hour for each activity (receiving, put away, replenishment, picking/selecting, and last-mile delivery).

Z-pick layout: A z-pick warehouse layout methodology centers the naming protocol around the actual movement of a picker or selector. When coupled with a Serpentine layout—changing the direction of travel every other aisle—z-pick results in almost a 40 percent reduction in total travel time. That reduction in travel time equals a much lower order cycle time, and higher productivity in the highest labor demand activity in any warehouse.

Catalog Harmonization/Rationalization: The process of determining what products are necessary to provide the health practitioner in support of specific protocols (usually a commercial practice). Many public health supply chains do not have an annual review of stock that moves very slowly—this slow-moving stock is typically products procured in such small quantities that they incur high cost due to lack of procurement scale, and loss due to expiry. Commercial logisticians annually review what is necessary to provide and continuously eliminate product from the catalog that has an alternative protocol. This rationalization or harmonization is closely related to the Pareto Rule or Principle.

Guide to Winning the Logistics Game

Chapter 1. Determining efficiencies: What is Consuming the Labor?

The first consideration for transforming your warehouse operations is to understand what is taking the most time, and what could be done more effectively and efficiently. Improving inventory turnover is arguably the most impactful change you can make.

Inventory turnover

What is inventory turnover and why does it slow down the process?

The time from when a quantity of a product is received at a warehouse until the time the last unit of measure of that product is issued from the warehouse represents one turn of inventory. The **inventory turnover ratio** (ITR) — also called **unit turn ratio** (UTR) — therefore, is measured as the number of times the inventory turns. It is usually measured as turns per year, but it could also be measured over a different period of time, especially if there is a seasonal pattern of consumption.

This is the inverse of months of stock (MOS), which states the length of time it will take to turn the inventory, e.g., 6 MOS will turn one time in 6 months. It's important to think of products in terms of inventory turns so that you can manage it from an aggregated perspective.

How important is inventory turnover to your operation? When we ask warehouse managers worldwide to determine the key factor to make their operations more effective, they unanimously ask for more warehouse space. However, is that really what they need? While warehouse space is indeed important, using the available space effectively is even more crucial.

Inventory turnover ranks among the **top three variables** impacting the supply chain, alongside cost and seamless orchestration of all activities—including procurement, customs clearance, receiving, put away, replenishment, picking, and loading. Further, shifting from periodic inventory control to perpetual inventory, has a significant impact. We'll discuss this, as well as inventory cycle counting, later in the guide.

Rather than focus on acquiring a bigger warehouse, logisticians should prioritize increasing inventory turnover speed. Warehouse operators work around the clock to ensure the timely receipt and processing of products before their scheduled distributions. Once that's complete, the receiving cycle restarts for the next distribution. The shipping department waits for the product to be received, stored, and made available for picking—and then must immediately begin outbound picking, staging, and loading the deliveries to complete their distributions.

Issues can arise if purchasers of public health products (e.g., government) don't coordinate with the downstream supply chains like warehouses or clinics. If purchasers make infrequent bulk purchases, this can lead to slow inventory turnover—sometimes warehouses hold so much inventory that product can't even be moved. This also results in **increased costs and expired or damaged products**. Receiving dates also become limited due to warehouse congestion, leading to longer order-picking times. This imbalanced cycle is caused by low delivery frequency to service delivery points, health outposts, and hospitals and a lack of coordination between warehouse operations.

In contrast, commercial operators in the private sector receive and ship products simultaneously. The techniques described in this guide are identical to those used in the private sector to achieve effective coordination.

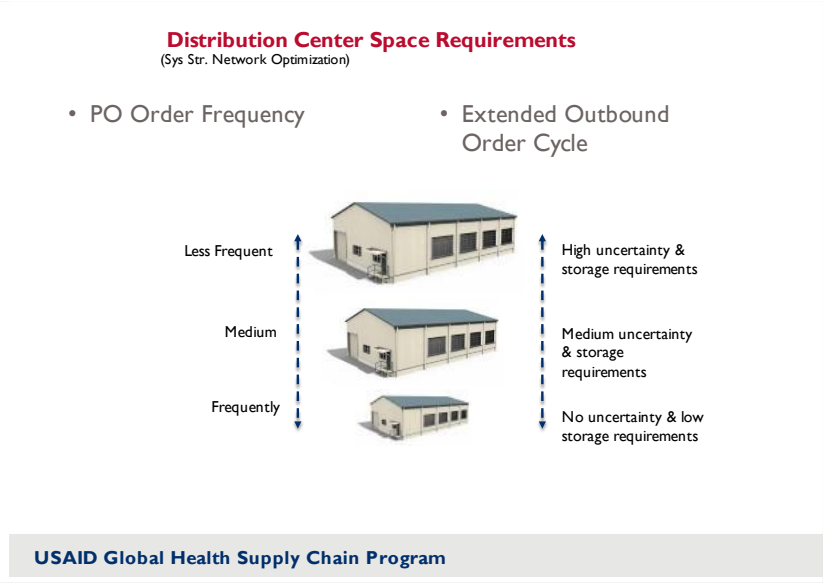
To summarize, public health supply chains operate slowly for two primary reasons – infrequent procurements and lack of coordination among all procurement entities and the supply chain. Now let's learn more about these roadblocks and how to address them.

Did you know? In private industry, ITR often is measured in terms of the value of goods, while UTR is measured in terms of units of goods. In this context, since many commodities **in public health supply chains** are donated, we will use ITR and UTR interchangeably to mean **the number of units issued divided by the average inventory level (in units) over a given time period.**

Infrequent procurements

Pharmaceutical companies in the commercial sector typically turn their inventory about eleven times in one year, maintaining just over a month's inventory. However, national public health system stores (or warehouses) usually range between 1.5 and four turns annually, with three to eight months of inventory on hand, even for the fastest-moving commodities. Some categories, such as essential medicines, have an inventory turnover of less than once, resulting in over a year's supply being held in stock. Extended storage periods in the warehouse lead to costs without any return in value due to **product expiry**. Studies report that up to 40 percent of a product's value is spent on slow-moving inventory.

TIP: Increasing the frequency of delivery at the national level through multiple receipts with smaller quantities per delivery can help distribute the workload more evenly over time. The impact of this approach on a warehouse is displayed in the graphic below.



How do you know if your **inventory turnover rates** are correct? Generally, turnover rates for national level warehouses or distribution centers should at least match the frequency of delivery to their customers, including SDPs, health outposts, hospitals, and clinics. For instance, if deliveries to a clinic occur every other month, we would aim for a minimum of six warehouse turnovers per year (12 months divided by two). **All products must rotate through the warehouse at a rate that matches or exceeds the delivery frequency**. You can calculate these turnover rates for individual products, specific commodities, or warehouse inventory.

What about outside storage? Slow-turning inventory can be dangerous and increase costs. Once the inventory levels exceed 85-90 percent of the total capacity of the warehouse, both productivity and safety of the operations are significantly compromised. With a **congested facility** full of inventory, managers may be tempted to store inventory outside of the warehouse, by renting external storage, or even build a larger warehouse. Costs for both would be exorbitant. The repercussions of overcrowding, expiry, and overhead costs (to increase storage capacity) can result in the **loss of up to 40 percent of the value** of slow-turning inventory. Outside storage should only be considered during very limited peak times, even if inventory is slow turning.

Lack of coordination

Issues with orchestration of activities cause delays in receiving, put away, replenishment, and more. These delays, all components of slow inventory turnover, create bottlenecks and increase the **work in progress (WIP)**. WIP decreases the flow of people and goods through the supply chain by creating unnecessary work buffers between activities. Essentially, it means that staff are getting in each other's way. The private sector manages to reduce WIP by measuring and tracking the **throughput** of all activities. Throughput is the number of units processed per hour for each activity (receiving, put away, replenishment, picking/selecting, and last-mile delivery).

We will go into further detail on how to measure, use, and manage throughput in Chapters 6 and 8, on implementing Plan, Do, Check, Act (PDCA) and the Daily Planner.

Harmonization: One approach to reduce warehouse congestion and improve inventory turnover is to review the need for the full catalog of essential medicines. Public health professionals call this process harmonization, which involves reviewing and potentially eliminating duplicate product items. It not only increases demand for the remaining items but also has the potential to reduce their costs. The commercial sector conducts this activity at least yearly; they call it *assortment rationalization*.

Increasing inventory turnover

In addition to freeing up significant warehouse space and decreasing costs, there are other tangible benefits of increased inventory turnover:

- **Increases shelf-life and reducing expiries at all levels of the supply chain.**
- **Reduces the need for on-hand inventory insurance.**
  To illustrate this, consider a warehouse whose inventory is valued at $50 million, and their inventory turnover is currently at two per year, with six-months of supply on hand. If you improve turnover from two to four per year (twice as frequent), you reduce the standing inventory to $25 million. This significantly **lowers the insurance cost** (based on value of product in the warehouse) because you reduced the amount of stored product. By

implementing this small but significant change, the value of that cost reduction can be allocated to procure additional life-saving pharmaceuticals for patients.

- **Keeps stock levels below 90 percent utilization of available warehouse space.** When capacity exceeds 90 percent of available space, it reduces the efficiency of product processing activities and eventually causes gridlock. A reliable **warehouse management system (WMS)** requires a minimum of ten to fifteen percent of warehouse bin locations to be open and available for product put away during the receiving process. With not enough open bin locations, receiving will slow down or stop altogether. Moreover, any product that is not confirmed within the WMS is unavailable for picking. This results in a buildup of WIP – unfinished work – further slowing down processes and movement of goods.

 A warehouse management system, or WMS, is a stock keeping system working in near real time. It allows the user to track and identify exactly where in the warehouse their inventory is, the batch numbers assigned, and expiry dates. A WMS, often electronic, is the primary tool for the distribution center operator, much like a hammer is to a carpenter.

Chapter 2. Optimizing Picking/Selecting: Low Effort with High Impact

Once you evaluate what challenges your warehouse is facing, you'll need to take the next, most logical step to reduce WIP and improve your ability to turn over inventory. There is one activity that will have the greatest impact and require the least amount of effort to address – improving your picking/selecting process. This section will dive deeper into warehouse challenges, explain why picking/selection is a good improvement area, and demonstrate how the different components of your warehouse layout can impact this critical activity.

Why picking/selecting?

Picking/selecting is the most extensive, time-consuming activity and uses the largest segment of your team. It consumes up to 70 percent of total warehouse labor when the team is handling product in units smaller than a carton, and up to 50 percent of total warehouse labor when handled at the carton level.

Picking/selecting refers to identifying and gathering products for delivery, typically done one delivery at a time in public health, often for a single SDP. This process is called "per invoice" or "per list." It resembles grocery shopping in that you have a list specifying the items and quantities needed. In the warehouse, a picker or selector follows their *pick list,* moving through the warehouse aisles to collect the products, ensuring they match the required batch numbers, expiry dates, quantities, pack sizes, and other specifications. Once the order is fully picked, it's loaded onto a vehicle and delivered to the SDP.

Commercial operators understand that a WMS should be configured to optimize warehouse picking/selecting, and they start by using assigned **pick slots**, also known as **fixed bins**. In the public health sector, most warehouse operators pick or select product directly from their original placement upon initial receipt. Often, the receipt locations are at a height that makes picking or selecting items when standing at the ground level unsafe. In these cases, forklifts, ladders, and multiple people are required to pick/select product. To optimize this process, product should be assigned to a specific location and that location consistently used—convenient to the ground level—to pick or select from. The product is replenished to the assigned pick slot/fixed bin to ensure proper expiry rotation.

The private sector's best practice is to **combine picking and packing into one activity**. Throughput measures the pace of these activities in product units processed per hour (UPH). It is inefficient when more staff are needed to perform the same activity and handle the same quantity of units. Combining picking and packing, or **interleaving**, can maximize throughput and reduce inefficiencies. Another example of interleaving is when a forklift operator simultaneously puts away the received product and makes replenishments for picking.

The next section will cover the most common replenishment types and strategies.

Picking/selecting types and why they matter

Product can be picked/selected at (1) the pallet level, (2) carton level, or (3) less than full carton level (picking at less than a carton is known as each pick, fine pick or loose pick). Full pallet picking/selecting is usually reserved for items with high volumes and quantities, such as cotton balls, LLINs, surgical gloves, and personal protective equipment (PPE). The next level, carton or case picking/selecting, is the most common in the commercial sector. It is up to **five times more efficient** than the less than carton/case level pick (each pick). In the public health sector, each pick is the most common unit of measurement used for picking/selecting. It is also the most time-consuming and costly.

Picking/selecting at the "each pick" level in the public health sector is driven by outdated minimum and maximum ordering rules. Orders that fall into this category include:

1. Ordering to meet a planned demand level for a set number of months and ordering everything in the catalog regardless of actual need.

2. Deliveries are not sufficiently frequent which leads to a desire to "top off" inventory while awaiting the next delivery.

In the private sector, the frequency of customer deliveries is based on the total product required for each site. It is not a "one size fits all" approach, using the same delivery frequency for both large hospitals and small clinics. Each location has a customized schedule based on their client needs.

The **over-reliance on the minimum and maximum reorder levels** leads to overstock at clinics, making inventory rebalancing practices opaque and increases the likelihood of product expiry. If you operate in a resource-constrained environment, there are only enough funds to **put the right product in the right place the first time**.

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Given the information presented above, public health warehouses should consider shipping products in pallets or cartons rather than individual units (eaches) to reduce the labor and time for picking/packing, auditing, loading, and unloading.

Using pick slots/fixed bins

As mentioned earlier, the most common, efficient, and easiest to manage approach for picking/selecting carton or less-than-carton quantities is to utilize pick slots/fixed bins.

Going grocery shopping: Imagine going to your favorite market with your shopping list, similar to staff picking/selecting items in a warehouse. How difficult would it be to find the items on your list if they changed the location every time you went or placed them seven meters, or 23 feet, from the floor?

Now, imagine that not only is the market laid out in the same order as your list, but everything is always located within reach and in the exact same location. Moreover, to ensure proper stock rotation, the groceries are replenished in *first-expired, first-out* (FEFO) order. In a warehouse, this translates to moving items from the overhead rack bin locations down to the pick slot/fixed bin before they are needed.

Even when using pick slot/fixed bin strategies, each pick activities make up 70 percent of warehouse activities. This ratio will never change, which is why it is important to optimize your picking/selecting activities, as they have the greatest impact on time and labor. By implementing the recommendations in this guide, you can achieve significant time savings.

Warehouse layout to optimize picking and slotting

*"We determine for each item its optimal **storage mode**, optimal **allocation of space**, and optimal **storage location** within its appropriate storage mode. As a result, slotting significantly impacts all of the warehouse key performance indicators, productivity, shipping accuracy, inventory accuracy, dock to stock time, warehouse order cycle time, storage density, at the level of automation."*
- E.H. Frazelle, PhD

Now that we know the advantages of implementing a fixed bin strategy, let's explore how to create an optimal layout. Picking/selecting activities account for up to 70 percent of total warehouse time. Surprisingly, up to 50 percent of that time is spent traveling or walking between Pick Slot/Fixed Bin locations. And up to an additional 15 percent of the time spent picking/selecting is consumed searching for the product or its location.

The key to productive picking or selecting has not as much to do with picking itself but rather with optimizing the time spent when you are not actively picking. Excess travel time throughout the warehouse and the struggle to locate items to pick/select is the enemy of efficiency. As a distribution center operator, you should aim to continuously identify and remove non-value-adding activities—traveling between fixed bins/pick slots is the largest.

Using the Pareto Rule

The **Pareto Principle**, named after economist Vilfredo Pareto, specifies that 80 percent of consequences come from 20 percent of the causes, asserting an unequal relationship between inputs and outputs. This principle serves as a general reminder that the relationship between inputs and outputs is not balanced. It is often applied in supply chain when thinking through how to manage product in an efficient and logical way, and mitigate risks/costs.

Another way to think of the Pareto Principle, or when applied, the Pareto Rule, is that 80 percent of a particular outcome is attributed to 20 percent of the contributing factors. When applied to warehouse picking/selecting, you could say that 80 percent of the total commodities to be picked or selected comes from only 20 percent of the catalog assortment.

This becomes especially obvious when comparing commodities for a particular health area, which typically consist of fewer than 500 assorted products in a warehouse, to the assortment of essential medicines, which can include 3,000 or more products on average. When analyzing the historical movement of outbound essential medicines from a distribution center, it is common to find many catalog items have not activity recorded over the previous 12 months. Using the Pareto Rule, we can safely assume that of the total 3,500 assorted products (program and essential meds), only 20 percent – or approximately 700 distinct products – represent 80 percent of the total outbound volume.

The Pareto Rule shows us that we should prioritize these 700 most frequently shipped products and that their optimal slotting location is closest to the outbound dock, minimizing travel time and maximizing picking productivity.

Note that when slotting for the optimum layout (to eliminate excess travel time)—and determining which products should be available for picking closest to the outbound dock— you should consider the quantity and the overall volume of outbound units picked. To do this, look at total units multiplied by the actual product dimensions, which can be calculated using the following **formula:**

To determine which products are making up the greatest portion of the total outbound volume of your warehouse:

Quantity picked/selected (individual product's daily average outbound movement divided by total of all quantities picked (provided by the WMS)) multiplied by **actual product dimensions**.

In Zambia, the GHSC-PSM project supported the Zambia Medicines & Medical Supplies Agency (ZAMMSA) as they shifted their operations to perform better as a major public health distribution center in their region.

They conducted product profiling to best slot their most frequently shipped items. They applied the Pareto Rule and found that the products highlighted in yellow (in the picture to the right) made up 80 percent of their outbound. This meant that they should prioritize these products (and the activities/labor required to move these products). By analyzing their products and product movement, they were able to shift their warehouse configuration and plan activities/labor accordingly, which can improve efficiencies.

SKU	Units Shippec	Weekly Volume	Weekly shipped m3	Pick Slot
EM0524	13200	3675505680	23.56	Floor/Bulk Stack
LAB003	880	3631440384	23.01	Floor/Bulk Stack
EM0645	10400	3300710400	22.31	Floor/Bulk Stack
EM1610	10300	3188533920	22.05	Floor/Bulk Stack
EM1600	35600	2911154400	21.99	Floor/Bulk Stack
SUT014	4200	2784418560	20.38	Floor/Bulk Stack
EM1280	9600	2353454592	7.31	Modified Super Slot
LAB098	250	2286360000	4.13	Modified Super Slot
MS2037	240	2186096640	3.22	Modified Super Slot
MS2215	4500	2113511130	2.89	Modified Super Slot
SUT014	3100	2094615936	2.44	Modified Super Slot
ARV006	5096	2093027872	2.02	Modified Super Slot
EM1602	12800	2040090624	1.98	Modified Super Slot
EM0328	7996	2013710355	1.83	Modified Super Slot
EM0096	3659	1979714147	1.01	Modified Super Slot
MAL000	844	1614538240	0.92	Modified Super Slot
EM0030	2096	1609929216	0.89	Modified Super Slot
SUT012	2420	1594123309	0.75	Modified Super Slot
THT001	1900	1260559104	0.63	Regular Slot
EM0245	6720	1246335552	0.61	Regular Slot
ARV007	7680	1196881920	0.58	Regular Slot
MAL000	560	1194547200	0.44	Regular Slot
MS2818	404	1186867968	0.38	Regular Slot
SUT012	1958	1121699040	0.35	Regular Slot
ARV007	3271	1116631083	0.31	Regular Slot
RH0001	16000	1098603520	0.28	Regular Slot
TB0048	240	886329600	0.20	Triple Slot
LAB007	130	861490240	0.01	Triple Slot
EM1628	1200	821145600	0.09	Triple Slot
SUT013	1200	802568832	0.06	Triple Slot
Total weekly cubic meters			166.63	

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You do not need a sophisticated, location-specific WMS to assign fixed bins/pick slots and improve your picking process. In fact, many operators manually assign their highest moving product to a specific location. Assigning even a few of the most frequently handled products to specific fixed bins/pick slots frees up a significant amount of labor for other tasks. You can also measure warehouse efficiency in terms of **hit density**, the ratio of time spent picking to the amount of travel time

required. A high hit density signifies efficiency. If a warehouse area has a high hit density compared to other areas, products that need to ship most frequently should be placed in that area. The overall goal is to simplify the picking/selecting process when possible by minimizing both travel time and searching.

Cubic Movement

Effective slotting is not solely based on picking/selecting. Always review product cubic movement (using the formula provided above) and re-slot when necessary. A best practice for adjusting/re-slotting is to seek the input of the people doing the work, such as the pickers/selectors. Even if there is no immediate benefit to moving a product's Pick Slot, valuing the staff's perspective and trusting their expertise will inevitably result in efficiencies that justify re-slotting efforts.

Sort all products based on their **outbound cubic movement**, with highest closest to the door and the lowest furthest away. After you've established your "perfect" picking layout based on these calculations, you should identify someone that is responsible for thinking these factors through on regular basis, as these measurements will change over time.

For a commercial logistician, it's best to revisit product slotting continually. Product profiles are not static and change over time due to evolving demands and packaging changes. A skilled slotting technician can oversee this task and given the efficiencies they can identify, they will pay for themselves and more, and give you a competitive edge.

Design with recipient in mind

When planning your layout, consider emulating your clients' stock room and putting yourself in their position, facing high-pressure situations daily while dealing with sick patients. Imagine how they would handle sorting through the repack boxes you have sent them. How easy have you made it for them to open, sort through, identify, count, and stock them in their stock room? By mirroring their stock room with your Pick Slot layout, you make their lives a little easier at no additional cost to you.

Chapter 3. Taking Your Layout to the Next Level

This section will demonstrate how to optimize different aspects of your warehouse (now distribution center) layout so that WIP is reduced and other efficiencies are in place to increase inventory turnover.

Racking

We've talked about where within your facility items should be placed. Now we will discuss the best ways to use the racks they are stored upon.

Calculating rack openings and pallet sizes

To determine the appropriate rack opening for the pick slot/fixed bin, multiply an item's average daily outbound quantity by its volume dimensions to calculate the total outbound cubic movement (see earlier sections). This represents the total daily product movement through the pick slot. **A higher outbound cubic movement indicates the need for a larger rack opening.** The goal is to

properly size the pick slot to hold at least an entire shift's worth of product without causing any waiting time for the picker/selector during replenishment. Minimizing waiting time is crucial in a distribution center as it does not add value.

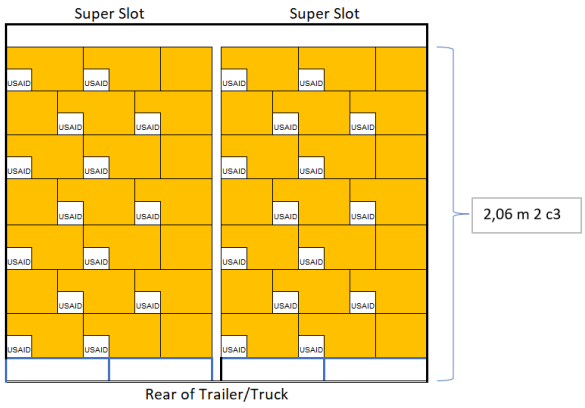
Note: Aim for standardized pallet rack openings and avoid customizing openings to avoid wasted space in warehouse rack locations. Select-a-rack storage systems are standardized, but offer flexibility in size.

The correct pallet rack openings for a distribution center are determined by three factors:

1. Simplifies the unloading and putting away process.
2. Minimizes the need for product replenishment from a reserve location to a pick slot (the permanently assigned floor-level location for the specific product picking/selecting).
3. Reduces travel time during the picking/selection process.

Wherever possible, work with procurement agents to palletize inbound loads to enhance efficiency before even opening the trailer or truck door. You should first think modularly – consider each part independently – and then integrate these modules later to create a comprehensive solution. Use standard pallet racking in your warehouse, which employs just three or four commonly used sizes to optimize space utilization and reduce unnecessary labor. You can interchange a range of the standardized rack sizes based on what you calculate is needed. This is determined based on the cubic volume of the products and the minimum interior height of a 40-foot shipping container as a standard measurement. See measurement guidelines in the slot diagrams below.

Establishing both standard minimum and optimal rack opening heights in your warehouse is advisable. Excessive customization can result in items not fitting correctly and, as a result, lead to wasted warehouse space and labor. Commercial logisticians use these standard pallet opening sizes in their racks to fully utilize the space and eliminate non-value-adding labor, such as spending excess time unloading and consolidating products on the dock or creating additional work by using incorrect pallet openings.

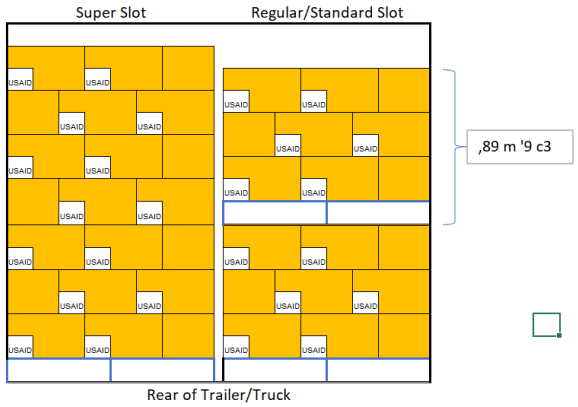


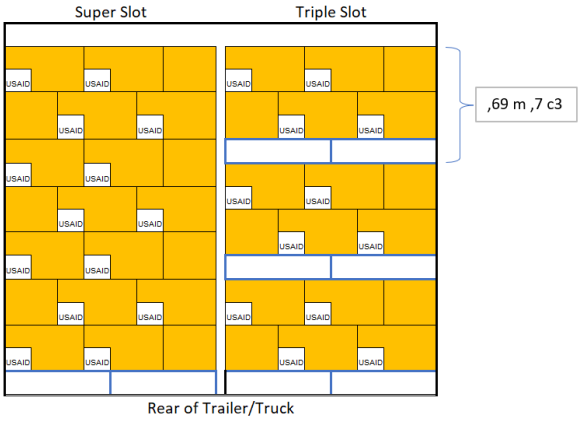
To minimize pallet handling and labor, the height of pallet rack openings should match the dimension of the load being handled. Rack openings need to accommodate the load without requiring excessive product breakdown on the receiving dock. A pull-off load is typically floor stacked and full container height, minus the actual pallet and a small clearance. This pallet configuration is shown on the left and often called a **Super Slot**.

As mentioned earlier, pallet rack openings should align with industry recommendations for the minimum interior trailer height. For a 40-foot normal-height container, the minimum trailer height is 2,350 mm. The maximum height for a Super Slot or single pallet is calculated by subtracting 144 millimeters, which is the standardized euro pallet height, plus an additional 144 millimeters for put away forklift clearance. That gives us a height of 2,062 mm (2.06m^2 as displayed in the super slot graphic).

However, it is important to note that most products requiring that much volume would be typically placed in a floor stack area rather than a pallet rack.

The universal standard opening, **Regular/Standard Slot**, is designed to accommodate two pallets of product, (using euro pallet measurements) and the additional safety clearance. This standard pallet opening for both pallets, minus the minimum trailer height of 2,350 millimeters, measures 887 mm (.89m) for the product and pallet (see regular/standard slot diagram).





The other common pallet rack opening (shown in the triple slot diagram) is based on the container dimensions minus a small clearance, divided by three. This opening is known as a **Triple Pick or reserve slot opening**. Using the Pareto Rule, a Triple Pick is used for product that is still best suitable for palletization but has a lower total outbound movement volume.

The final type of pallet opening is called a **Modified Super**. If you picture the inside clearance height of a container with a triple pallet configuration, the remaining height is a Modified Super. This pallet opening works very well for light and stackable products with high volumetric turnover but may not be suitable for floor stacking. Modified Super pallet opening is well-suited for products that have fast cubic turnover.

The inside height of the trailer/container is the common denominator. It's essential to consider not only the product's height but also the pallet's height (which can vary within a stack).

Now let's explore a smaller unit of measure inside of the warehouse.

Non-pallet level pick slots/fixed bins

Flow rack, gravity feed, and carton flow roller systems have a remarkably high hit density. Each warehouse bay can accommodate as many as 40 to 50 Pick Slots with almost no travel time. While replenishment is necessary, each operation's total forklift put away and replenishment time constitutes less than 15 percent of the total warehouse time. Moreover, replenishment from the rear of the system reinforces correct product rotation following the FEFO principle.

The gravity feed, carton flow, and repack pick slots are typically assigned to products with lower volumetric movement and are usually picked in less-than-carton quantities. Most public health average order profiles would benefit from this technology, leading to a reduction in travel while picking, as the typical supply chain professional often picks items at the individual unit or each level.

Existing ordering practices typically focus on eaches (single unit/lowest unit of measure). However, the transition from a "warehouse" mindset to a "distribution center" approach makes your inventory and picking/selecting practices more efficient, resulting in cost savings. You should use the cost savings to increase the frequency of customer deliveries. This shift will instill confidence in your ability to maintain stock levels, so ordering will continue to be in smaller quantities but more frequent. Consequently, you can gradually shift to ordering in inner packs or cartons for only those required products until the next scheduled deliveries (because the outbound quantity will remain consistently high/frequent). As the supply chain becomes more efficient and the delivery frequency reaches a satisfactory commercial level, the unit of measure can be increased to the inner pack or carton level. **This reduces dependency on flow rack/gravity feed rollers type of slot** and increases the picking efficiency, resulting in a five-fold decrease in the required time.

Bookcase Racking

Bookcase racking is suitable for the slowest-moving product in your catalog. However, it is not ideal for large or uniquely shaped cartons and does not utilize the overhead space or the existing locations within the bookcase. Bookcase racking can be a good option for areas with overhead obstructions or limited space where the traditional pallet racking cannot be used, such as mezzanines. However, bookcase racking can pose security and loss prevention issues due to limited visibility of the activity behind the racks; pallet racking does not have this issue because they don't have closed backs.

Replenishment

When implementing a pick slot/fixed bin strategy, it is essential to consider how to keep the bins/slots full and rotate correctly following first-expired, first-out (FEFO) and first-in, first-out (FIFO) principles. The rack locations above fixed bin/pick slots are called reserve slots/locations. They are filled upon purchase order receipt and replenished when required. The replenishment process reinforces the correct rotation as a designated forklift operator is responsible for completing this task. This approach also eliminates unnecessary travel time going up and down on a rolling staircase, forklift, and cage to move between different levels. If a forklift operator is lifting a picker/selector up and down to retrieve products, this action is considered part of the picking/selecting process and adds more time to the process.

FEFO and **FIFO** principles dictate that products which are the "oldest" or received before newly arriving products should be shipped or delivered first, to limit the chance of expiry. The processes and layout of your distribution center should facilitate this flow.

There are two types of replenishment to a pick slot/fixed bin:

- **On-Demand Replenishments:**
  An on-demand replenishment is made during the active picking/selecting process based on the demand for all shipments scheduled for that day or shift. As the picker/selector requires the product, forklift operators replenish from the overhead reserve location. The process works very well but may occasionally result in wait times for the picker/selector. As discussed earlier, assigning the product based on its average outbound cubic volume (quantity x dimension) can minimize the frequency of on-demand replenishments.

- **Forced Replenishments**
  Forced replenishments are done based on the available space in the assigned pick slot/fixed bin. When your assigned locations are correctly organized, the process eliminates almost all waiting time during the picking/selecting activity and reduces on-demand replenishments. If you have a product with high outbound cubic volume but only standard openings are available, you can use a technique called "flexing" the pick slot/fixed bin. It involves using adjacent floor-level bin locations to avoid multiple forklift replenishments and picking/selecting operations from them. It is important to note that it may cause a risk of not following FEFO/FIFO. To reduce the risk, it is crucial to establish a comprehensive standard operating procedure to ensure proper rotation.

If the rack openings are incorrect as a result of using the wrong pallet opening size or not purchasing items in full pallet quantities, it leads to large gaps of space between the top of the product on the pallet and the load beam above it. This gap represents lost storage space or "cube." The underutilization of space shown in the picture above can greatly impact the entire warehouse.

Fortunately, there is a solution. You can adjust the rack openings with an adjustable rack like the one pictured here, without using any specialized tools. Most warehouse racking is made for exactly this purpose. Your goal should be to maximize the storage within each pallet position while maintaining the consistency of pallet rack openings and heights.

Remember to leave enough clearance for forklift put-away and replenishment ease. Do not compromise storage space for safety or risk causing product damage. Adjusting the product size to fit the opening correctly will decrease replenishments and reduce the total number of pallets needed for storage upon receipt.

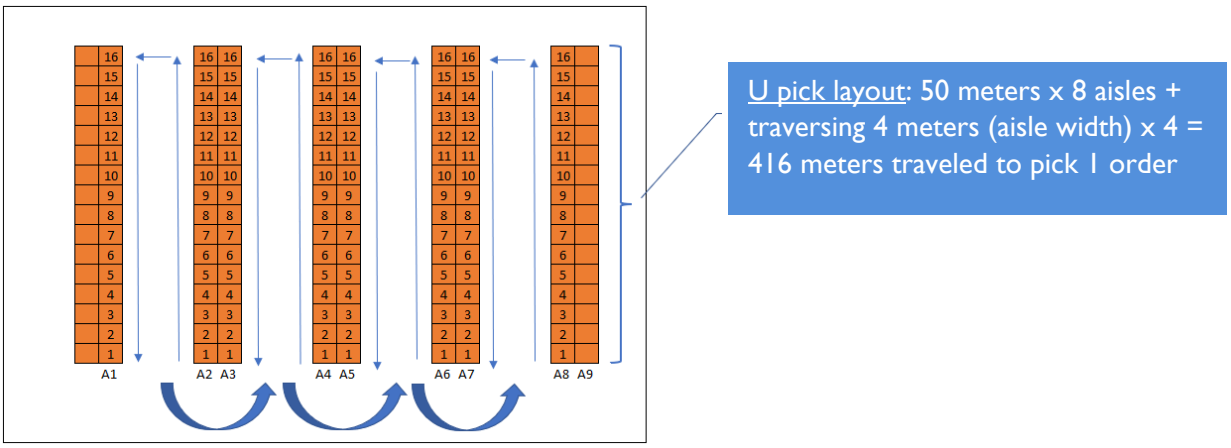
Chapter 4. Planning your picking strategy

Once you have arranged your product, it's time to think about how to best pick/select the product.

Methods for Fixed Bin/Pick Slot Replenishment

Z-pick and Serpentine picking

Now let's go back to our grocery store analogy and examine how we "shop" in the field of public health today. Most operators in public health supply chains use a "U" pick pattern, showcased in the diagram below.



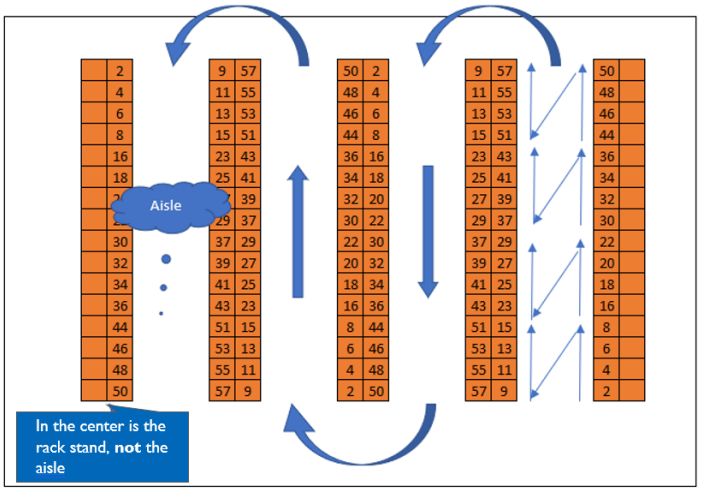
U pick layout: 50 meters x 8 aisles + traversing 4 meters (aisle width) x 4 = 416 meters traveled to pick 1 order

Imagine walking down one side of an aisle and selecting things from your list. The methodology commonly seen in public health warehouse layouts, but it is not a best practice in WMS configuration.

We must start by correcting the understanding of what an aisle is. The aisle is the passageway for personnel and material handling equipment and not just a stand of racks. Just like a postal worker delivers mail to both sides of the street simultaneously, an aisle should be seen as a warehouse street. A WMS cannot differentiate between sides of an aisle and generates pick lists or sheets in alpha-numeric order without considering the physical location of the items. The WMS does not discriminate based on the physical bin location.

Warehouse managers should ideally organize a Pick List to match the WMS format, in alpha-numeric order. Surprisingly, many public health warehouses sort Pick Lists in product naming order. The Pick List generated by a WMS directs the picker/selector down one side of the aisle to pick items, turn at the end, and progress back the way they came, picking along the way. In most public health warehouse layouts, the picking pattern is reversed at the end of the aisle, forcing the picker/selector to backtrack and start all over again in the next aisle. This is because, as noted earlier, the WMS captures orders and generates pick lists/pick sheets in alphanumeric order but lacks knowledge of actual locations.

The diagram above shows a stand of racks that is fifty meters long and eight individual aisles in the WMS. Following the depicted U-pick pattern, the total distance traveled through the warehouse for one order is 416 meters. Would you prefer to shop in a market where you have to backtrack to the beginning of each aisle, or one where you are shopping from both sides of the aisle in a single direction? The distribution center layout in the following diagram remains the same, with the same distances, but applies a different way of labeling product locations to reduce travel time.



Implementing a Z-pick layout involves naming the locations differently so that the WMS will generate a picklist in the shape of a "Z". This reduces the total travel distance from 416 to 208 meters. This method streamlines the process for the picker/selector. The **reduced travel time** immediately results in a 17.5 percent decrease in the total labor time for all warehouse/ distribution center activities. **The reduction in picking/selecting time exceeds 35 percent**. The only cost involved in that is the cost of the new rack labels. It is important to note that every other aisle in this layout reverses the naming protocol and direction to eliminate any backtracking. The direction the picker moves through the warehouse is described as "serpentine" because of the way they snake through the racking.

Note: To reduce congestion on your shipping dock, consider distributing pick sheets or pick lists in reverse-route order. That means that the first order to be loaded and unloaded at the clients' location should be the first one picked. Product selected, staged, and loaded in that order, eliminates a crowded and congested shipping dock. As a professional logistician, it is your daily job to identify and eliminate any WIP. In this case, it means avoiding picking or selecting the product too early to prevent interference with the loading dock workflow.

Chapter 5. Receiving and dock flow

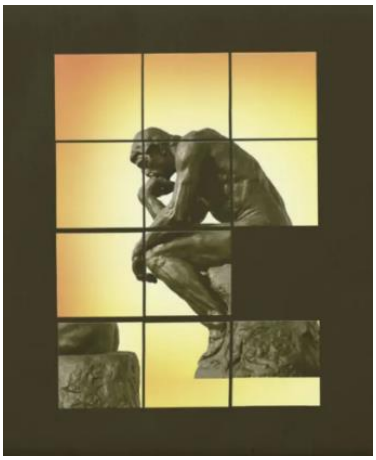
Now let's discuss the impact of the receiving function on your operation, particularly concerning inventory turnover and picking/selecting.

Receiving Best Practices

As we already know, much of the warehouse time is spent picking/selecting. We also know the adverse effect of slow-turning inventory. Another factor is uncoordinated receiving practices, which directly contribute to stockouts, slow down picking/selecting, and prolong inventory turnover.

In most WMSs, a purchase order cannot be considered complete until all the products have been received, confirmed, and put away in the designated warehouse bin locations from that specific purchase order before allowing it to be picked/selected. The best practice from the private sector is to assign multiple purchase orders per container/load but never use the same purchase order across multiple containers/loads. Although using one purchase order per multiple containers may be easier for procurement, it significantly increases the lead time for product availability and disrupts distribution center operations. This is further exacerbated when different implementing partners work independently and overwhelming quantities of containers/loads arrive simultaneously, putting a strain on receiving activities.

In the commercial world, it is considered best practice to have the product received, put away, and confirmed to a WMS bin location within four hours of unloading on the receiving dock, making it available for distribution. Most often in public health, it takes more than 72 hours to complete these tasks. Slow turning inventory and lack of coordination between activities is the most common cause of that delay.



A common misconception in public health supply chains is that a warehouse should always operate at 100 percent capacity. Any warehouse management system needs between 10 to 15 percent of the warehouse bins open to function effectively. It is crucial to keep the capacity below 90 percent to use the system and move product off the receiving dock. How would you complete the picture below if all squares were filled? A WMS operates in the same way. If you have over 90 percent used capacity in your warehouse, you are gridlocked, creating an unsafe work environment. The picture to left is a puzzle that demonstrates the only way for the tiles to move around is to have an open space. The same can be said for a warehouse.

Receiving schedule and balancing

After you have set your warehouse racking for the correct openings (see Chapter 3), the quickest way to control receiving inefficiencies is to establish a receiving schedule and coordinate all inbound scheduled loads. Set a date and time for each load and communicate that expectation to the procurement partners. Balance the number of workloads across the receiving schedule by scheduling higher quantity loads/ more complex purchase orders (usually orders with more stock-keeping unit (SKU) counts per load) earlier in the day. This helps avoid overwhelming certain parts of the operation so everyone can complete their part within the scheduled time.

	Monday			Tuesday			Wednesday			Thursday			Friday		
	Pallets/cartons	Carrier	PO	Pallets/cartons	Carrier	PO	Pallets/cartons	Carrier	PO	Pallets/cartons	Carrier	PO	Pallets/cartons	Carrier	PO
8AM															
9AM															
10AM															
12Noon															
1PM															
2PM															
3PM															
Total															

Use a simple paper log like the one shown above to keep track of doors, times, and days, and set an unloading time limit to balance your reception workload. Instruct drivers on the expected unloading time. Whenever possible, avoid scheduling loads directly adjacent to each other on the log. Typically, there's some separation between them, with the space in between ideally reserved for building support columns. Be sure to keep product unloading marshaled into a designated area. Keep the receiving dock continuously turning over in preparation for the next load. Prioritize late loads and do not schedule complex loads towards the end of the day. If a late load arrives and you do not immediately need the product, schedule it for a later slot, possibly even the next day.

Don't be afraid to adjust the schedule to optimize efficiency and reduce congestion. Do not be discouraged by resistance or the belief that "this will never work here." Even some compliance is a good starting point. When drivers comply and arrive on time, reward them by unloading their trucks promptly because you and your team are prepared. Truck owners know that they are not making money when the wheels are not turning, so they are motivated to be on time if they know they will be unloaded on time. Your careful scheduling will balance the workload and move things along in a coordinated fashion.

Each country and warehouse deals with products in different units of measure. It's more efficient to handle products at the highest unit level, as working with eaches (less than carton level) involves opening cartons and counting individual items, whereas cartons are quicker and easier to handle. **Moving one carton is equivalent to moving 12 eaches.** The most efficient method is working at the pallet level, where a single forklift can manage several thousand eaches. Palletizing involves stacking cartons in layers, making it easy to load, unload, and move them within a warehouse or an SDP. Palletize the loads wherever possible. This can help you make up for time spent picking/selecting.

If you have a truck-level dock, consider using an inexpensive manual dock leveler, as shown in the picture to the right. They bolt onto the face of the receiving or shipping dock and are manually operated to create a bridge between the building's finished floor level and the truck. This enables the user to use forklifts, electric pallet jacks, or hand jacks to reduce the time for loading and unloading.

To improve efficiency, consider implementing staggered start times per activity. In commercial operations, put-away forklift operators typically begin their tasks at least one-half hour after receivers/checkers. This approach prevents team members from waiting and ensures more effective time use. Remember, the goal is to complete all activities every day by the end of the shift.

Good Pallet Management: The Basics

A pallet, also called a skid, is the structural foundation of a unit load used for efficiently handling and storing goods during transport (loading and unloading). The flat ridged structure of the pallet supports goods while being lifted by a forklift or pallet jack, allowing them to be stored in racks or stacked on the floor. While most pallets are wooden, they can also be made of plastic, metal, or recycled materials.

Pallets come in various shapes, sizes, and types, but this guide will focus on the two that are most commonly used in the public health supply chain setting.

Pallets can be purchased new or used. Many vendors will use low-quality C-grade pallets for loading/transporting commodities to customers. These pallets are often a one-time-use pallet and should be discarded after unloading/receiving. Only the higher quality pallets are suitable for storage, so **product/cargo must be repalletized before being put away in the distribution center/warehouse**.

Euro and GMA pallet grades

The **Grade A Euro Pallet** is a quality pallet suitable for heavy goods, with a four-way entry for easy handling by pallet jack or forklift from any side. It can handle evenly distributed weight loads up to 2500 kg and is stackable, rackable, and reusable.

Dimensions: 1200 x 800 mm; Weight: 24 kg; Approx. Load Capacity: 2500 kg.

The **Grade B Euro Pallet** is suitable for light to medium loads. It can handle evenly distributed weight loads up to 750 kg.

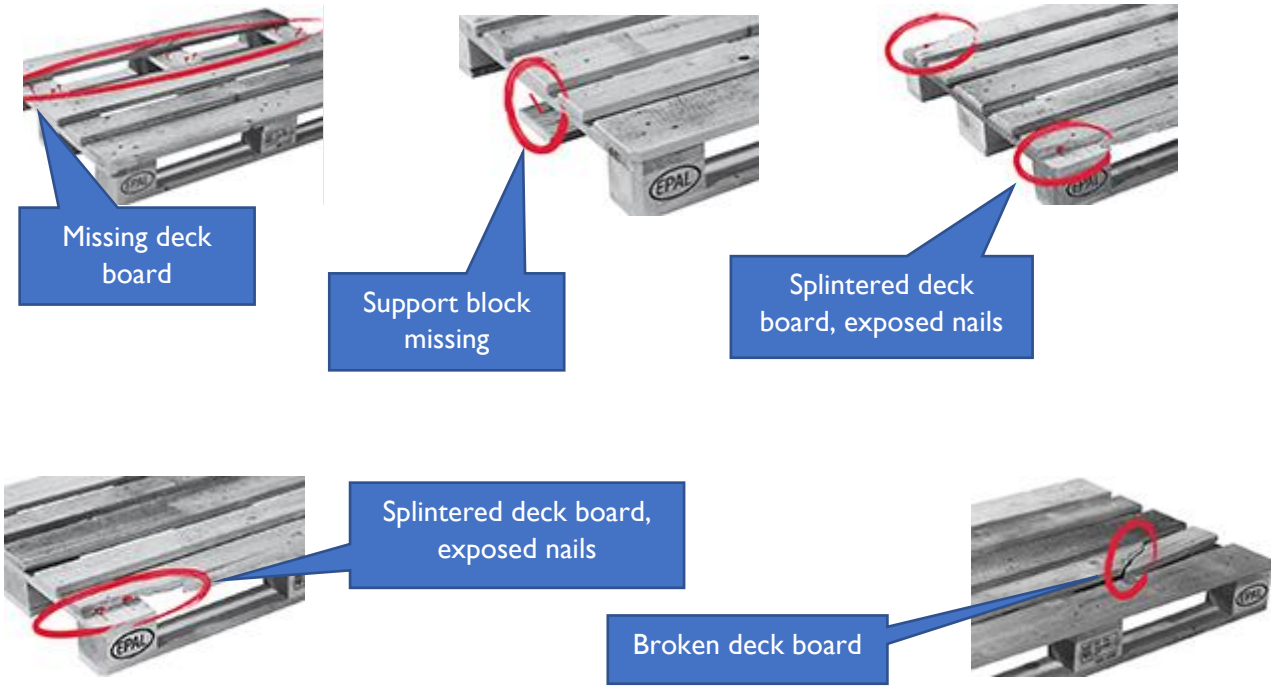
Dimensions: 1200 x 800 mm; Weight: 10 kg; Approx. Load Capacity: up to 750 kg.

The **GMA pallet** measures 40 x 48in. Unless you will floor load, you should remove GMA pallets from your supply chain. They are oversized and will not fit in a standard euro pallet configuration.

This section will proceed to discuss only Euro Pallets as they are the pallet we recommend using in the countries the GHSC-PSM project and USAID support.

Pallet concerns/issues

If Euro pallets display one or more of the following faults (see images and captions below), the pallets should be removed from the supply chain, to be repaired or recycled.



Additional characteristics of unusable pallets

- The safe working load is at risk due to rot, decay, heavy splintering, or damaged stringers.
- The pallet is contaminated, which can lead to the contamination of the payload/product, such as
  - Infestation by termites or insects
  - Water soaked, containing/affected by mildew and mold
- Heavy splintering is visible on several blocks, posing health and safety concerns and leading to excess material handling equipment (MHE) costs (e.g., forklift drive wheels may have a shortened lifespan).
- Unacceptable components have been used (e.g., boards that are too thin or blocks that are too small).

Most countries require certification and/or proof of fumigation of wood pallets to clear customs.

Common pallet configurations and compositions

Plastic 4-way pallet. Suitable for all warehouse purposes

Cardboard 4-way; EURO-recyclable. Not fit for warehouse use.

2-way GMA pallet; wood/waferboard. Not suitable for general warehouse use.

Chapter 6. Take it a step further: Tools to optimize

Lean methodology and the plan-do-check-act cycle (PDCA)

We have discussed the biggest impacts on your distribution center activities but have not touched on them all. Every activity is important in the team's success and may vary slightly across different operations/teams. Now that we have explored what impacts your team's productivity, let's explore how to manage all of these activities together. The theory of constraints, throughput, Lean and the PDCA cycle, are concepts and tools needed improve all activities. Understanding these concepts will allow you to use the Lean/PDCA Cycle and the Daily Planner to efficiently lead and coordinate your distribution center team and manage the daily strategy.

Throughput measures the effort required to complete an activity within a given timeframe, calculated hourly, weekly, or monthly, typically in units per hour. An increase or decrease in throughput reflects the operational efficiency or inefficiency for that period. A higher throughput indicates a more productive and efficient operation. Any supply chain relies on throughput to determine the velocity at which the entity achieves its objective. Throughput in a for-profit entity drives profit, while in a low-resource or public health supply chain setting, it's crucial to focus on how well it achieves its mission with limited resources. Throughput in this context means delivering vital medicines to constituents in the shortest time, with minimal effort and financial resources.

Throughput by activity and unit. The end goal of managing throughput is not pushing people to do more. It is the opposite. Managing throughput for all activities in a coordinated fashion removes barriers for everyone. By coordinating throughput across all activities, you can eliminate work in progress (WIP). The aim is to ensure that each activity operates at optimal velocity, neither slowing down nor overwhelming the following integrated activity. Releasing work prematurely into the system overloads already constrained resources and hinders completing the projects on time. In a distribution center, receiving ten trucks of inbound product in a day is meaningless if you cannot put away all ten truckloads. The key is to complete all work for each activity by the end of each shift or day.

Theory of Constraints: Optimizing activities to reduce WIP

Each supply chain activity is a link in the chain, only as strong as the weakest link in the chain. This "weak link" is the constraint – e.g., no one available to receive products.

Continually identifying and addressing constraints (i.e., getting leaner) should be your goal as you move toward becoming an optimized distribution center. The more parties involved (e.g., implementing partners), the more constraints will be introduced.

Little's Law

The original formula of $L=\lambda W$, was developed by John Little as a mathematical way to explain Queuing Theory and was published and popularized by Philip M. Morse (of World War II fame) in the 1950s and 60s. The theory explains that the number of customers in a queue (L) equals the long-term average arrival rate of customers (λ) multiplied by the average time that each customer spends in the queue (W). In simple terms, this means that the more customers in the queue, the longer the average waiting time for each customer. A crowded market before a major holiday is an excellent example of this – it takes a long time to finish shopping because of the many people in the queue.

This concept was then adapted and applied to Lean manufacturing and birthed **process lead time** (PLT). PLT and Little's Law became classic metrics for measuring process velocity.

To apply Little's Law to Lean and PLT, the formula's components were rearranged as **PLT=WIP/ER**.

PLT is the time it takes for an object to go through a process from when it first enters until it exits a processing center (e.g., a warehouse). PLT is equal to the **WIP**, the average number of items in the queue or line, divided by the **exit rate (ER)**, which is the average number of items that exit the process per a specified unit of time.

What does that mean in terms of operating the distribution center? We've learned that picking/selecting takes up to 70 percent of the total time for all warehouse activities (much like your time spent shopping at the market). You cannot achieve efficient operations by adding more people to a picking activity. Adding more labor to the activity only creates WIP and slows the entire process. The main benefit of applying Little's Law is eliminating WIP. To achieve this, we must balance different activities using a Daily Planner.

Introducing the Daily Planner to Eliminate WIP

A Daily Planner is a simple tool used to anticipate the workload for each activity within a given shift. (See example in the annex of this guide.)

Data sources for the workload can be straightforward, such as a receiving schedule with the number of loads, cartons, or pallets. It could also be a WMS and the number of replenishments required or the amount of units to be picked. Additionally, it can be based on the operator's understanding of the expected workload, considering historical knowledge of specific factors such as busy periods like the first month of the fiscal year (due to the release of procurement funds) or scheduled distributions for large catchment areas with large hospitals or many patients.

To ensure tasks are completed within the scheduled shift, divide the amount of work required for each activity by the hours scheduled. For example, we anticipate shipping 12,500 units for the scheduled routes tomorrow. Using the Daily Planner, we learn that our average picking/selecting throughput is 175 units per hour. We calculate 12,500 units divided by 175 to get 71.43 hours needed for picking/selecting. Given an 8-hour shift with a 30-minute lunch break, we divide 71.43 hours by 7.5 (8-hour shift minus 0.5 for lunch) to find that we need 9.52 pickers/selectors. Repeat this process for all activities and staff them accordingly.

The Daily Planner is implemented using plan-do-check-act (PDCA) methodology. Plan all activities the night before and start the shift the next day with a brief kickoff meeting. Make adjustments if needed due to last-minute changes like unplanned employee absences, emergency orders, or canceled scheduled receiving.

How often do we use PDCA/Daily Planner?

As noted earlier, you should plan your next day before you leave. Estimate the quantity expected in each area, the number and complexity of incoming loads, and the number of pallets to put away. Determine the size of your picking/selecting day. The biggest question is how many staff are required and what areas they should be assigned to accomplish all tasks.

Start the shift by reviewing any changes: are there more or fewer loads than expected? Are there unexpected orders to fulfill? Did everyone show up for work? Based on any changes, make adjustments and assign staff where they are needed; balance the workload to get everything done that day.

Continuously review and adjust the activities throughout the day and ensure a balanced workload and completion of tasks by the end of the day. Soon enough, you will notice WIP diminishing, and your distribution center efficiency will improve. Using PDCA is putting the Lean methodology into action. After using the Daily Planner consistently for about two months, operators should see consistently better performance and efficiency.

Around the eighth week, you will see the maximum reduction in WIP, and your actual throughputs will reflect your existing system and process. However, do not get too comfortable. It is often said that if the distribution center seems to be running smoothly, it might coast downhill. This is when experienced operators know they should look for ways to remove or mitigate non-value-added activities.

The following chapter is a compilation of ways to eliminate some of the constraints by area, to increase efficiencies by reducing WIP.

Chapter 7. Ways to Eliminate the Constraints by Area

This chapter is an easy-to-follow list of considerations for different areas of distribution center operations. It applies the concepts described in detail earlier in the guide to everyday activities.

Receiving

To create balance in the inbound schedule:

- Schedule loads across the week and the day.
- Avoid scheduling complicated loads toward the end of the shift.
- Assign doors for a specific load/PO and direct drivers accordingly.
- Prioritize late loads should to the end of the shift.
- Avoid staging large or complicated loads directly adjacent to each other.
- Stagger the start times for specific activities. For example, put-away forklift operators should not start at the same time as receivers if the product won't be ready for an hour after check-in. Stage the product closest to the put-away area and receive it first, working backward toward the truck you are receiving from. This enables ready access to pallets for forklift drivers and continuously clears space for future receiving.

Put Away

Use transport vehicles instead of forklifts wherever possible. Forklifts are not the most efficient material MHE for transport as they can only move one pallet at a time and are complicated and expensive to maintain. Use them for their intended purpose - lifting and lowering products from warehouse racking. Transport the product to them and keep them efficient. Avoid overloading any area with receiving and balance forklift labor where and when needed.

Ensure your rack openings adhere to global standard openings, as described in Chapter 3. Maximizing pallet storage efficiency is the best way to reduce the number of pallets you have to move in the first place.

Select the right doors and assign loads to be received close to their storage location. **Minimize travel time.** Parking the truck in the right spot is easier than transporting 40 pallets unnecessarily far.

Consider introducing **interleaving**, which means assigning multiple functions to the same operator. For example, a forklift can put away products, bring empty pallets to the loading or receiving dock, and make replenishments simultaneously. Utilizing a **cross-dock methodology** wherever possible is the ultimate example of interleaving for put away. Instead of putting away the product, take it directly to the shipping dock, which can be a significant time saver. Keep constraints like FEFO in mind; rules must be followed. While the methodology may not be suitable for all products at all times, it completely eliminates the need for put away, replenishment, and picking when properly coordinated.

Optimizing racking usage

Use bookshelf racking in places with limited overhead space or on a mezzanine. However, you should also keep security issues in mind, as it is hard to observe picking activity in the area.

Put Away Storage – What <u>to</u> do

To the right is an example of inbound commodities from the vendor on a standard euro pallet (strapped). The product can be safely floor stacked or stored in a rack.

Below is an example of proper pallet placement in racking and the excellent use of storage space.

Put Away Storage – What <u>not</u> to do

For a Euro **non-rackable** plastic pallet, it is essential to repalletize the product onto a wood pallet or a rackable plastic pallet during receiving. Alternatively, store the product on the warehouse floor.

The photo on the right demonstrates why a non-rackable plastic pallet should not be used on the storage racks – it is unwieldy, unsafe, likely to break and cause unforeseen damage, and does not optimize product configuration.

Safely Stacking Empty Pallets

Pallets are a necessary part of the supply chain and need proper management. This means maintaining the pallets in good condition and removing the substandard ones from the inventory.

Consider the storage of empty pallets as well. The recommended safe stacking height for empty ready-to-use pallets inside the facility is six feet (1.8 meters). For wood pallets on the warehouse floor, stack them no higher than six feet (1.8 meters) in groups of four, leaving at least eight feet of space between groups.

- **Floor Stack/Bulk Stack:** If pallets are stacked higher than two meters inside the warehouse, they must be protected by an automatic fire sprinkler system, such as Early Suppression Fast Response (ESFR), following the national safety regulations.
- **Rack storage:** Avoid storing empty pallets in pallet racks unless the racks are protected by an ESFR sprinkler system.

Never stack or lean pallets on their sides

- **Outside storage:** If pallets are stored outdoors, they must not be stored against the exterior walls of the warehouse/distribution center. This is important for fire safety and rodent/pest control. Pallet stacking outdoors should not exceed fifteen feet (4.5 meters) high per stack.

To the right is an example of **extremely poor pallet storage conditions**. You can see that pallets are stored in ways that are likely to damage them, make them susceptible to fire and animal risks, and could cause a major safety issue if they shift in any way. They are also stacked directly against the building.

Replenishment

Make sure to size the pick slots/fixed bin appropriately to hold an average of a week's worth of outbound volume (quantity x size). Putting the right product in the right size location based on its total movement reduces the number of pallets needing replenishment. If a product is slotted/assigned to a regular opening but moves more than one pallet per week, consider assigning it to two adjacent locations. Be mindful of proper batch and expiry rotation.

Shift to forced replenishments wherever possible. Fill the fixed bin/pick slots up based on their capacity and not on demand for the product. **Forced replenishments** work better when completed during an off-shift when there's no selection/picking. Forklift operators can work unincumbered by pedestrian traffic. It's also the best way to increase picking/selecting throughput without hiring more staff and dealing with Little's Law.

Keep the pick slots/fixed bins full to make the pickers/selectors twice as productive. On-demand replenishments occur when pickers/selectors empty the product from a pick slot/fixed bin and then wait

for a forklift operator to replenish it. While on-demand replenishments can never be eliminated, forced replenishments significantly reduce their occurrence.

Ensure your WMS can sort forced replenishments in bin/aisle order. Complete all replenishments in a given aisle from reserve storage locations in the rack and in bin/aisle order. Use a transporter, not a forklift, to move the pallets to the correct fixed bin/pick slot. This method is used by commercial operators and allows you to **replenish up to 40 pallets per hour**.

Upon receipt, collaborate with your WMS configuration person to direct products closest to their designated fixed bin/pick slot. Virtually every WMS has this capability. Also, use interleaving by assigning put away, replenishment, and returning empty pallets to the reception area.

Picking/selecting

The easiest way to increase productivity in picking/selecting is to **not** pick/select in less-than-carton quantity. Picking carton/case quantity is **five times quicker** than picking at less-than-carton quantity (also known as eaches, loose pick, or fine pick).

Productive picking/selecting is not just about the process, it's about what you do when you're not picking/selecting. Several activities adversely affect picking/selection efficiency. Poor inventory control practices lead to empty fixed bin/pick slots due to lost product and employee waiting times while the issue is resolved. Overcrowded and poorly laid out aisles cause delays, as demonstrated by Little's Law. The wrong product based on outbound volume slotted/assigned to the wrong fixed bin/pick slot can result in excess travel time. Untimely replenishment is a significant factor that creates **long order cycle times**, or the time it takes to complete all picking activities after the order has been released and loaded on the truck. Operators who switch to forced replenishments can typically reduce the order cycle time by at least 40 percent.

Picking/selecting productively has nothing to do with picking/selecting. It actually has to do with what you are doing when you are **not** picking/selecting. Some examples of waste during this time are:

- excess travel between picks
- congestion (people, product, and equipment)
- imbalanced shipping schedule

Staging/Loading

By now, you are starting to see that each warehouse activity can adversely affect others, often the next step in the process. The supply chain is like an actual chain. Imagine a 10-meter chain stretched out on your loading dock. What happens if you try to push it? It ends up twisted and tangled, and your efforts accomplished nothing. This idea can be applied when streamlining all activities before the loading dock by eliminating constraints or bottlenecks. To move the chain forward, you must improve each activity and maintain the balance between them. Remember, a chain moves forward when it's pulled, and that starts on the staging/loading dock.

One quick way to decrease congestion on the staging/loading dock is to **pick/select in reverse route order**. Assign pick lists/orders starting with the last delivery point on that route first, followed by the second to last, and so on. Doing so will allow you to reduce dock congestion and allow loaders, auditors, and security to focus on their current tasks without unnecessary distractions.

Many public health supply chains measure on-time arrivals for their clients at clinics, hospitals, and health outposts, but very few measure on-time departures. One of the best ways to arrive on time is to leave on time. Establish specific outbound departure times throughout the shift and monitor them closely. By creating **waves of departures throughout the day**, you can reduce the amount of WIP and congestion, resulting in only one or two loads at a time.

Palletize wherever possible. The speed of your distribution center will start to increase as you eliminate the work in progress, benefiting everyone involved. Avoid overwhelming your loading dock with a fast-paced process. Palletizing outbound loads is a standard private sector practice because it is quick, reduces load damage compared to floor-loaded product. You will also see much faster unloading times if the transporter uses a lift gate (see photo on the right) or the hospital or clinic has a loading dock. It is also much easier for medical professionals to receive and stock the medications in palletized form.

Chapter 8. PDCA: What is next?

Where do we go now that you have spent several months practicing PDCA every day and starting to eliminate non-value-added activities to reduce bottlenecks? Let's consolidate our performance trends into a tool to start seeing a longer-term view and establish seasonal historical tracking.

A **labor report** is an Excel-based tool designed for your distribution center. It uses your daily throughput performance for a given month, and compares it to last month's performance, helping to understand the seasonality of your business and long-term staffing/hiring trends. (See example in annex of this guide.)

> *"Self-determination is the key to localization."*
>
> - Ralph Titus Jr., Director of Systems Strengthening, GHSC-PSM project

Integrating **financial tracking** with the labor report comes next. At full implementation, this is described as Activity Based Costing/ Activity Based Management (ABC/ABM), the last step in gaining complete, independent control of your supply chain. ABC/ABM is the methodology private sector supply chains use to operate their supply chains and compete with each other.

Below are some of the benefits of consolidating your daily planner into a monthly labor report:

- **Monthly performance trends:** Understand the factors affecting your distribution center.
- **Modeling trends in volume and hiring needs:** Plan ahead of your labor needs and anticipate any required resources.
- **Financial stability of the warehouse:** Achieve better vendor pricing, enhanced availability of goods, and reinvest in your supply chain by implementing a strategic capital reinvestment plan.
- Competing with the private sector by adopting their **effective strategies**.
- Return on investment **(ROI) calculation for innovative technologies**: Use data to determine if a given technology or MHE suits your operation.
- Provides a **baseline for ABC/AMB**.
- **Market value enhancement:** Mastering ABC/ABM can enhance your team's expertise and market value like your commercial supply chain peers.
- **Ensuring value:** A public health warehouse worker is invaluable to the health of their fellow citizens. But essential medicines only have value in the hands of an individual who needs them, not in an overcrowded and slow-moving warehouse. Using Lean and ABC/ABM ensures that product value is protected by eliminating waste in the supply chain, basing decisions on actual need, and ensuring supplies get to patients rather than sit in a distribution center.

Conclusion

Congratulations! You have made it through this guide, including its guiding principles, best practices, key formulas and considerations, and lessons learned from others as they transition from the "warehouse" mindset to a "distribution center" approach. You've heard the evidence and methods for significantly reducing costs, including how to increase your inventory turnover and eliminate WIP, how to optimize your facility layout and schedule, what pallets, racking and slots to use to make everyone's jobs easier, more efficient, and even safer. You've seen the tools and principles for emulating the success of the private sector and not relying on "how things have always been done." Now it's time to implement!

Annex: Supplemental resources

Exhibit 1. Commercial throughput metrics

Major Warehouse Activities, excerpt from *The Time, Space & Cost Guide to Better Warehouse Design, 2nd Edition, Napolitano M. Gross & Associates, Alexander Communications Group, 2003*.

Commercial Throughput Standards			
	Per Person/Per Hour		
Warehouse Activity	**Lower Range**	**Upper Range**	Units Per Hour
Lift Truck Pallet Movement (forklifts)			
Counter-balance	12	20	Pallets per hour
Narrow aisle reach	12	18	Pallets per hour
Narrow aisle articulating	12	18	Pallets per hour
Order Picking/Selecting (pieces)			
Pick-to-cart	30	100	Lines per hour (# of different products on a Pick List-not the total of the pieces picked)
Flow rack to container	100	200	Lines per hour (# of different products on a Pick List-not the total of the pieces picked)
Bookcase bin/shelf to container	60	150	Lines per hour (# of different products on a Pick List-not the total of the pieces picked)

Exhibit 2. Daily Planner

A commercial distribution center operator estimates the amount of work scheduled for the next shift and uses their estimated throughput to calculate how long each activity should take and then they staff accordingly. The goal is to finish all scheduled activities prior to the end of the shift and in synchronization across all activities.

Daily Planner for Central Medical Stores, Anylandia								
Date								
Day								
Function	Planned Qty	Throughp	Shift length	Required Staffing	Total hou	Hourly rat	Cost per activity	Cost per carton/unit
A	B	C	D	E	F	G	H	I
				(B/C)/D	(D*E)		(F*G)	(H/B)
Receiving	100	10	8	1.25	10.00	3.55	35.50	0.355
Putaway	1152	74	8	1.95	15.57	3.55	55.26	0.048
Picking	22354	23	8	121.49	971.91	3.55	3450.29	0.154
Packing	22354	27	8	103.49	827.93	3.55	2939.14	0.131
Loading	12125	48	8	31.58	252.60	3.55	896.74	0.074
							Total costs	0.763

Exhibit 3. Labor Report

A Labor report is a monthly rollup of all the daily planner results. The following example tracks not only throughput and labor, but costs as well. This allows the operator to understand the impact of overtime and outside variables like increased receiving or outbound deliveries.

Sample Monthly Labor Report–Throughput & Activity Based Financial Performance Tracking

Month Ending: June
Period Number: 3

Actual	x to $	Projected	x to $	Variance	x to $		Actual	x to $	Projected	x to $	Variance	x to $
$ 22,554,360		$ 11,510,185		$ 11,044,175		Sales	58,259,322		$ 34,530,555		$23,728,767	
						Receiving					-	
303,869		599,719		304,150		Units	2,051,383		2,156,434		(104,451)	
2,768		2,768		-		Regular Hours	8,304		8,304		-	
7	53			7		OT Hours	7		5		2	
102		121		(19)		DBL Time Hours	373		573		(200)	
2,877	3.73%	2,197		680		Total	8,684	4.38%	6,806		1,879	
193,451	0.85	111,751	0.37	81,700	(0.11)	Cost	587,313	1.01	355,754	1.03	232,159	(0.02)
314		273		41		Throughput	236		317		(81)	
						Picking					-	
163,531		170,913		(7,382)		Units	587,404		754,769		(167,365)	
346		346		-		Regular Hours	1,038		1,038		-	
-		5		(5)		OT Hours	-		5		(5)	
3		48		(45)		DBL Time Hours	16		145		(129)	
349	0.86%	572		(223)		Total	1,054	1.52%	1,707		(653)	
12,619	0.08	18,601	0.16	(5,982)	(0.11)	Cost	38,360	0.07	55,543	0.16	(17,183)	(0.10)
						Packing					-	
692		692		-		Regular Hours	2,076		2,076		-	
-		-		-		OT Hours	-		-		-	
-		39		(39)		DBL Time Hours	13		120		(107)	
692	0.00%	304		(212)		Total	2,089	0.62%	2,542		(453)	
40,745	0.18	67,202	0.58	(26,457)	(0.40)	Cost	123,766	0.21	189,836	0.55	(66,070)	(0.34)
						Lines	-					
-		-		-		Lines Per Hour	-		16		(16.00)	
157		116		41		P&P Throughput	187		178		9	
						Loading					-	
865		865		-		Regular Hours	2,595		2,595		-	
		-		-		OT Hours	-		-		-	
36		42		(7)		DBL Time Hours	159		233		(75)	
901	3.94%	734		167		Total	2,754	5.76%	2,309		445	
52,678	0.23	34,020	0.30	18,658	(0.07)	Cost	163,887	0.28	111,441	0.32	52,446	(0.04)
788		718		69		Throughput	755		843		(88)	
						All					-	
1,613,038		1,127,081		486,017		Units	4,123,353		4,101,320		28,033	
8,131		6,920		1,211		Regular Hours	24,393		20,587		3,806	
7		15		(8)		OT Hours	7		20		(13)	
141		499		(359)		DBL Time Hours	793		1,751		(959)	
8,279	1.78%	7,434		845		Total	25,193	3.17%	22,358		2,835	
463,376	2.85	385,779	3.35	77,597	(1.38)	Cost	1,425,663	2.45	1,167,813	3.38	257,850	(0.93)
195		152		43		Throughput	164		183		(20)	