



**IMPROVING PERFORMANCE OF WAREHOUSE
ORDER-PICKING PROCESS: A CASE OF ETHIOPIAN
PHARMACEUTICAL SUPPLY AGENCY ARBAMINCH
BRANCH**

MSc. THESIS

BY

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HAWASSA UNIVERSITY, HAWASSA, ETHIOPIA

DECEMBER, 2022

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PICKING PROCESS: A CASE OF ETHIOPIAN
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A THESIS SUBMITTED TO THE
FACULTY OF MANUFACTURING
DEPARTMENT OF INDUSTRIAL ENGINEERING
INSTITUTE OF TECHNOLOGY
HAWASSA UNIVERSITY

IN PARTIAL FULFILMENT OF REQUIREMENT FOR THE DEGREE OF
MASTERS OF SCIENCE IN INDUSTRIAL ENGINEERING AND LOGISTIC
MANAGEMENT

DECEMBER, 2022
HAWASSA, ETHIOPIA

SCHOOL OF GRADUATE STUDIES

HAWASSSA UNIVERSITY

ADVISOR APPROVAL SHEET -1

This is to certify that the thesis under the title “**Improving Performance of Warehouse Order-Picking Process: A Case of Ethiopian Pharmaceutical Supply Agency Arbaminch Branch**” submitted in partial fulfillment of the requirement for the degree of masters of science with a specialization in Industrial engineering and logistics management graduate program in the faculty of manufacturing. department of Industrial engineering. It has been carried out by Aman Demelash Alemu ID. NO IELM-R 0003/11 was under our supervision. Therefore, we recommend that the student has fulfilled the requirement and hence he can submit the thesis to the department.

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EXAMINER’S APPROVAL SHEET -2

We, the undersigned, members of the Board of Examiners of the final open defense by Aman Demelash Alemu have read and evaluate his/her thesis entitled “**Improving Performance of Warehouse Order-Picking Process: A Case of Ethiopian Pharmaceutical Supply Agency Arbaminch Branch**” and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of masters of Industrial Engineering in Hawassa University Institute of Technology, a faculty of manufacturing with a specialization in Industrial Engineering and Logistics Management.

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DECLARATION

Aman Demelash Alemu, declare that this work entitled **“Improving Performance of Warehouse Order-Picking Process: A Case of Ethiopian Pharmaceutical Supply Agency Arbaminch Branch”** is an outcome of my effort for partial fulfillment of the requirement for the award of the degree of masters of science with a specialization in Industrial engineering and logistics management graduate program in the faculty of manufacturing and has not been submitted for any degree in this University or any other Universities. All sources of materials used for the study have been duly acknowledged.

By: Aman Demelash Alemu

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Date_____

ACKNOWLEDGMENT

This research could not be possible without the help of many supporters. First and foremost I would like to thank the almighty God and the mother of Jesus, Virgin Mary for giving me the strength to finish this Thesis. My next gratitude goes to my major advisors: Dr. Fantahun Moges and Mr. Baharedin Abdella, head department of Industrial Engineering for their guidance throughout the research. Moreover, I would like to extend my deepest sincerest gratitude to my entire families, especial thanks to my father **Demelash Alemu** (MSc.), mother **Kassach Wondimu** (MSc.) and my elder brothers **Biruk Demelash**, lecturer in arbaminch university, electrical engineering department and **Tihitina Demelash**, resident engineer in south design & construction bureau for their encouragement, patience and grateful support throughout the whole graduate program and this thesis. Thanks for their kind cooperation in providing all the material and finance I needed. My final thanks go to EPSA Arbamich staffs and management team for their support by giving me their precious times.

Thank you everyone!

ABSTRACT

Researches in relation with improvement of order picking process are hard to find in countries like Ethiopia, as topics like this are overlooked. But studying on the improvement of order picking process is great for the field and looking at it in detail may bring changes in performances of warehouses, as it is necessary to look from the bottom to see the big picture or else looking only the big picture may not let us to know the root causes as needed. Being one of the most time consuming processes in the field of warehousing called, picking has the highest impact on the service level. In turn, from the warehouse activities picking is the most complex, labour intensive and costly. However, due to the customer demand fluctuation increased allocation strategy's need to be reviewed and adjusted over time for the reasonable utilization of warehouse space. Since the main goal of this thesis is to improve performance of warehouse order-picking process in Case of Ethiopian Pharmaceutical Supply Agency Arbaminch branch. Under this, it assess the current states of order picking process in warehouses of the agency, identify the type of storage system, picking strategy and bottlenecks in the warehouse, identify variables to improve overall order-picking time and propose solutions using mathematical and analytical models. This research applied the DMAIC (Define-Measure-Analyze-Improve-Control) model to improve the order picking process in case company warehouse. The order pick delays affected customer satisfaction, DMAIC helped the researcher to define the pick problems, measure the current pick performance, and analyze the root causes. For the analysis of collected data Microsoft Excel, Cause and Effect analysis, Pareto Chart analysis and POM-QM software was used. The finding of this research indicates that the performance of order picking process was affected by long searching time and lack of product knowledge. This phenomenon was caused due to random storing arrangement in the warehouse and poor pickers' educational background level. These top two problems were source of 80 % problem that cause delay in order picking process, so that they can forward for solution making. The researcher develops new assignment model formulation and propose conceptual framework as an improvement and control methods. The comparison result between before and after implementation of the storage assignment strategy indicates that there is a significant improvement in the order picking time, which was reduced by 34.4 minutes. Finally, the conclusion and recommendation were given.

Key words: Warehouse, Order picking, Order picking time, DMAIC model, Assignment model, Pareto chart, Cause and Effect diagram, Lean.

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LIST OF ACRONYMS

COI	Cube-Per-Order Index
DC	Distribution Center
EPSA	Ethiopian Pharmaceuticals Supply Agency
I/O	Input – Output
KPI	Key Performance Indicator
SKU	Stock Keeping Unit
WMS	Warehouse management System

CHAPTER ONE

1. INTRODUCTION

1.1. Background

Every distribution center (DC) has incoming and outgoing goods and As a result of warehouses, Customers do not have to wait for products, since they are already in stock. According to Tonelli Warehousing can be defined by three functions: receiving goods from a source, storing goods until they are needed by a customer (internal or external), and retrieving the goods when requested and plays a key part in the supply chain by connecting manufacturers and customers (Tonelli. et al; 2016). Warehouses nowadays are playing a pivotal role in the success and/or failure of business, as they are playing a critical intermediate role in between supply chain members, affecting both supply chain cost and service (Faber, N, 2015). For warehouses to function well there are warehouse operations which are performed on a daily basis in a warehouse, there are four main warehouse operations; receiving, storage, order picking and shipping/dispatching. To keep up with the changes in customer demand and to reach a higher customer satisfaction level, improvements in warehouse activities are needed. From the warehouse activities, the order picking is the costliest activity when comparing it to other activities (Frazelle, 2002). In this study a researcher going to focus on order picking.

Order picking is one of warehouse operations and is defined as a process of retrieving items from storage locations in response to a specific customer request; it is the most laborious and the most costly activity in a typical warehouse, with up to 55% of warehouse total operating costs (Tompkins et al. 2003) and 50% of the workforce of a warehouse (Strack and Pochet 2009; Berg and Zijm 1999). Bad performance of this operation may affect the whole supply chain through high operational costs and unsatisfactory service (Koster, Le-Duc, and Rootbergen 2007).

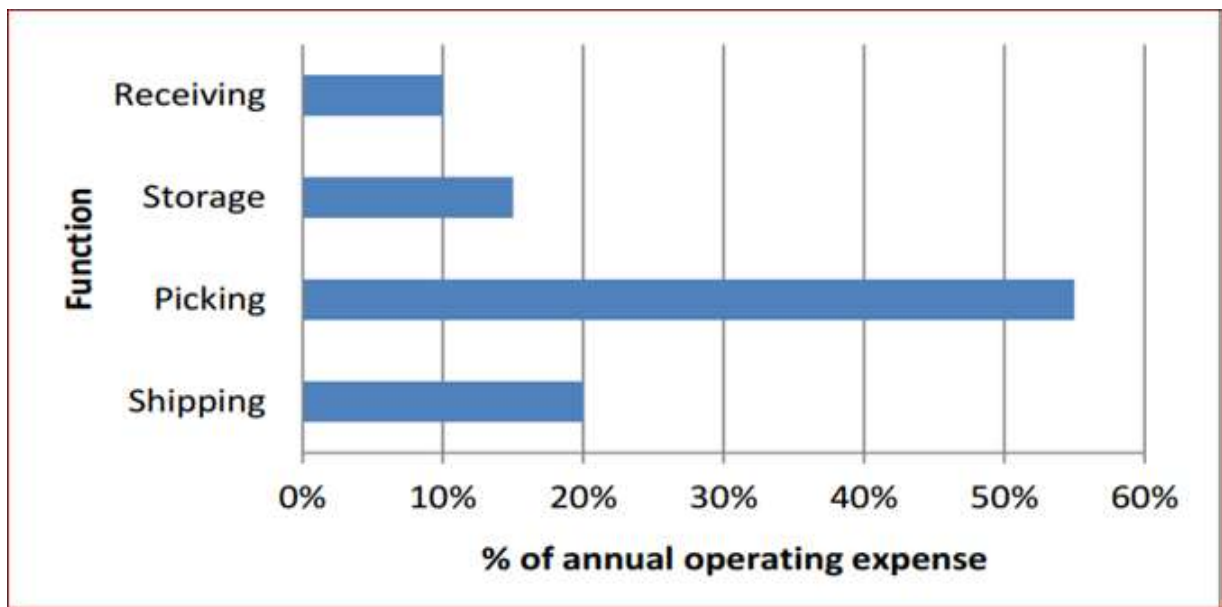


Figure 1-1. Operational costs in the warehouse (Tompkins et al.2010)

Order picking is critical to each supply chain, because underperformance results in an unsatisfactory customer service (Long processing and delivery times, and incorrect shipments), and higher costs from labor cost, and cost of additional or emergency shipments (Henn et al., 2013).

As this study focuses on distribution center of pharmaceuticals and medical supplies for health facilities in Arbaminch and around regions, pharmaceuticals and medical supplies are special commodities in the logistics and supply chain management as their quality and facility will be related to people’s life safety. All Pharmaceuticals and Medical Supplies have a defined shelf life and need a precise warehousing condition and these Pharmaceuticals and Medical Supplies require balance in between the availability of them and service demand from the public. The proper storage of Pharmaceuticals and Medical Supplies ensures their safety, efficacy, stability and quality; this can be achieved partly by storing Pharmaceuticals and Medical Supplies according to their specific storage condition separate from other non-Pharmaceuticals and Medical Supplies (Gizat Mola Kassie, Samson Mamo, 2014).

1.2. Statement of the problem

Order picking is a major logistic process in a warehouse, for this it can be considered as the main influencer of customer satisfaction. Order picking consists of receiving orders by each picker, traveling to the location of each item on the order, picking and then delivering the collected items to the dispatching area. In all these activities travelling routes, restrictions, and policies can affect the total processing time. The organization of order picking operation directly impacts the performance of distribution centers and there by the performance of the supply chain. (Bataineh and Khasawneh, 2016). Bad performance of this operation may affect the whole supply chain through high operational costs and unsatisfactory service (Koster, Le-Duc, and Rootbergen 2007).

Ethiopian Pharmaceutical Supply Agency, (EPSA) is an agency established for the purpose of distributing pharmaceuticals and medical supplies to the public at affordable price. As a result warehousing is one of the main core processes of the agency. Taking this in to consideration, based on short visit observation and interview with stakeholders indicated that, in the warehouse of the given distribution center, the agency uses ABC classification as storage allocation strategy, and it does not work fully is an issue. This means the classification loses its purpose presently, while random storage allocation is in use. The source of this problem is the item in a warehouse overfilled, and placed in nonadjacent locations. No popularity, demand frequency, affinity issues are taken into consideration, neither continuous evaluation of demand patterns are implemented in a warehouse now a day's. However, due to the items that I considered in this thesis is related to the healthcare sector, where delay or inaccurate picking might lead to more serious consequences as it will be related to people's life safety. Also due to warehouses of the agency are managed traditionally, the researcher feels it is necessary to conduct studies like this to improve the performance of these warehouses.

1.3. Research Question

- 1) What are the states of current order picking process in warehouse of EPSA, arbaminch?
- 2) What type of storage system and picking strategy should be used?
- 3) What are the challenges faced by warehouse managers and operators in practicing efficient order picking process?
- 4) What are the variables used to improve overall order-picking time in case of EPSA, arbaminch?
- 5) What are main criteria to be considered while developing allocation strategy?

1.4. Objective

1.4.1. General Objective

The General objective is to improve performance of warehouse order-picking process in Case of Ethiopian Pharmaceuticals Supply Agency Arbaminch Hub.

1.4.2. Specific Objective

In order to achieve the general objective, the following specific objectives are outlined.

1. To assess the current states of order picking process in warehouses of EPSA, arbaminch.
2. To identify the type of storage system, picking strategy and bottlenecks in warehouse of EPSA, arbaminch.
3. To the challenges in fulfilling well organized picking process.
4. To identify variables to improve overall order-picking time in case of EPSA, arbaminch.
5. To propose solutions using mathematical and analytical models.

1.5. Significance of the Study

The findings of this study will benefit the distribution center in understanding its warehousing practices and offers ground for the company to reduce its internal and external costs that will be resulting due to poor picking practices. This work brought more understanding to the question of warehouse management in the scope of the order picking process to improving their service level. Moreover, the study will possibly help by providing background material for future research in similar or in other sectors to use the findings for reference purposes in future related studies.

1.6. Scope of the study

Ethiopian Pharmaceutical Supply Agency (EPSA), as stated earlier, is a distribution center for pharmaceuticals and medical supplies for health facilities of the country. The agency has seventeen branches all over the country, and Arbaminch branch is one of this branches. So this research is about the improvement of performance of warehouse order picking process in case of Ethiopian Pharmaceutical Supply Agency Arbaminch branch warehouses because of the inability to cover and access the 17 branches throughout Ethiopia due to the geographical locations, time and budget restriction.

1.7. Limitation of the study

In this study improvement for the order picking process was developed through storage allocation strategy. Therefore, this thesis is limited to the planning level. Operational level of the picking process, like routing strategies, batching algorithms, as well as other warehouse activities as packing, loading or transportation are out of the scope. In addition, as order handling in warehouse is done manually, study is limited to a picker-to-parts picking system, while automated picking systems left out of the scope. Also possible changes in layout design of the warehouse or picking tools will not be considered, as it needs high budget and operational cost.

1.8. Organization of the paper

The research is organized into five chapters. Chapter One, contains the introduction part dealing with the background of the study and company, the research problem, objectives of the study, scope, and significance of the study .Chapter Two, introduces warehouse activities and picking process, following by discussion on order picking improvement strategies. In Chapter Three, the research methodologies are present. Chapter Four, presents the results and discussion of the study and finally, Chapter Five presents the major findings, conclusions, and forwarded suggestions for future researches.

CHAPTER TWO

2. Literature Review

2.1. Introduction

The importance of the order picking improvement has been acknowledged largely and deservedly has been taking place as a subject for the various researches over the past 50 years, with the attention paid to the different aspects throughout the time. Khodabandeh emphasizes that the importance of the order picking is valid for healthcare warehouses as well. As evidence, he provides a report by United Parcel Service, showing that picking and order fulfilment consumes 54% of the cost in the average healthcare distribution centre (Khodabandeh 2016). De Koster et al., discuss several recent trends both in manufacturing and distribution, which have made the order-picking design and management more important and complex. In manufacturing, there is a move to smaller lot-sizes, point-of-use delivery, order, product customization, and cycle time reductions. In distribution logistics, in order to answer new requirements of the customers, companies tend to accept late orders while providing fast delivery within tight time windows. Thus, the time available for the order picking becomes shorter (De Koster 2007). Gu et al. describe order picking problem as one of the most challenging among the warehouse operation planning concerns (Gu et al. 2007). While there have been several investigations on the general order picking problem, little research regarding order picking for a healthcare warehouses was found.

2.2. Warehouse operations

De Koster et al. defines warehouse as a place where goods are received, temporary stored, and released according to the customer requests. As consolidation point between supply and consumption warehouse also provides value-added for order fulfilment and, is the place where packaging of goods according to the specific sales orders, customization, inspection and assembly are performed (De Koster et al. 2007). Hausman et al. mentioned the efficiency of the order picking as a crucial factor considered at the stage of warehouse design. Correct storage allocation and suitable warehouse layout minimizes travel distance and the picking time, resulting in improvement of the total fulfilment cycle (Graves et al. 1976).

The organization of product in warehouse takes place through the following physical processes as shown in the figure below:-

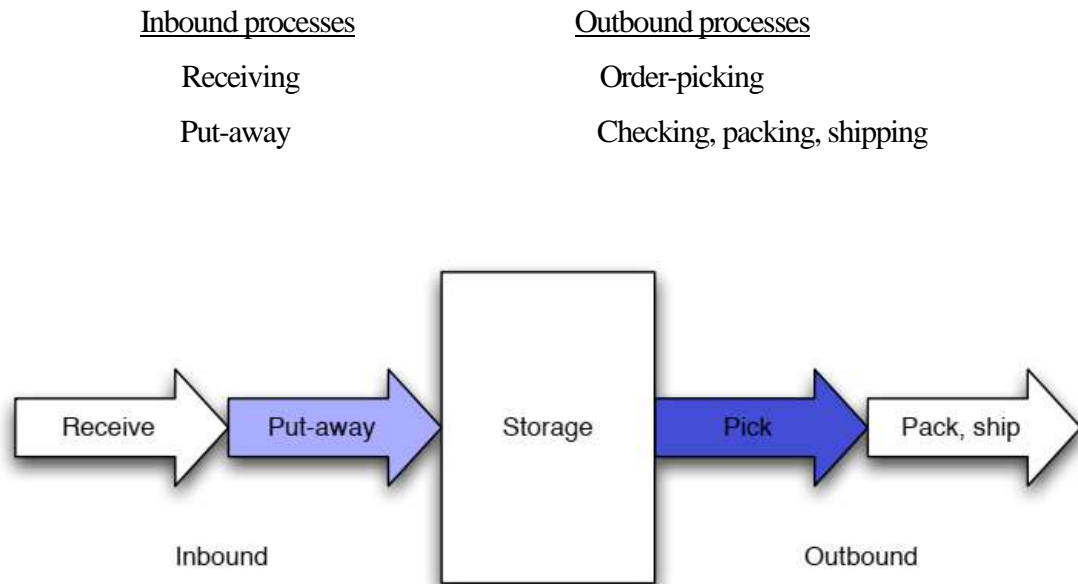


Figure 2-1. Warehouse operations (Bartholdi, 2016)

2.3. Order picking process

Order picking is identified as the most costly and labor-intensive operation in most of the warehouses, i.e. 65% of the total cost and 50% of the workforce of a warehouse (Strack and Pochet 2009; Berg and Zijm 1999). Bad performance of this operation may affect the whole supply chain through high operational costs and unsatisfactory service (Koster, Le-Duc, and Rootbergen 2007). Tompkins et al. describes an order picking, as the process of retrieving items from the storage in response to the customer request and defines picking as the most labor intensive and costly process containing around 55% of the total warehouse operational costs as shown in Figure 2-2 (Tompkins et al. 2010).

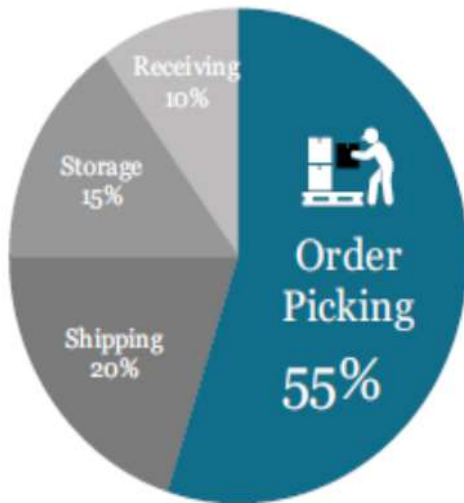


Figure 2-2. Warehouse expenses

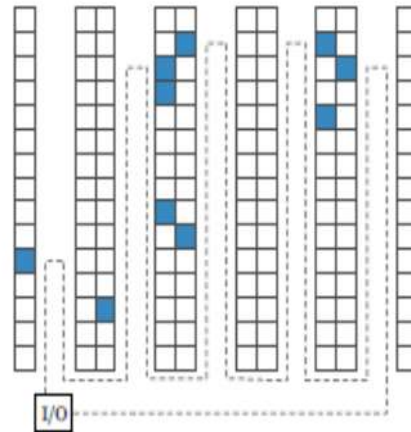


Figure 2-3. Example of order picking

Minimizing material handling cost or equivalently, traveling cost, traveling distance, or traveling time is one of the main objectives which researchers have strongly focused on when the goal is to improve order picking efficiency. Figure 2-3 represents order picking of multiple items in an aisles warehouse. Tompkins et al. showed that in fact, half of the order picker's time is spent on traveling (Figure 2-4). To the same conclusion went both De Koster et al. and Petersen by describing travelling of the order picker is the most time consuming activity usually estimated at about 50%. Therefore, typically the majority of the studies are dedicated to improve this vital process (Tompkins et al. 2010). According to Bartholdi and Hackman (2005), travel time is waste. It costs labor hours but does not add value. It is, therefore, a first candidate for improvement.

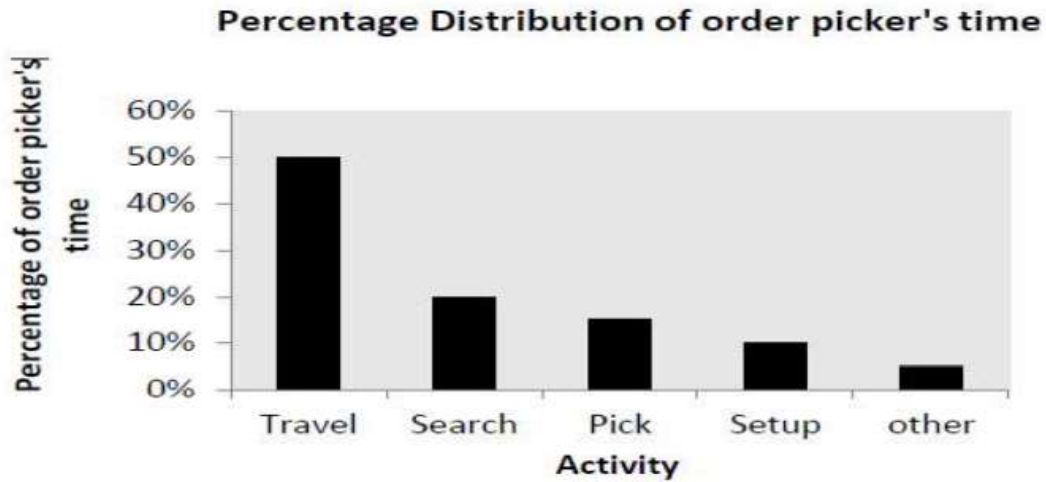


Figure 2-4. Order picker's time, adapted from (Tompkins, White et al.2010)

De Koster defines several order picking systems which are created to optimize the order fulfilment cycle (Figure 2-5). Three main systems are distinguished according to the order picking approach: picker-to-item, item-to-picker, and automated picking. In a picker-to item system, order pickers need to travel along the rack shelves to retrieve the items in their order lists. Same approach is used in the case warehouse of this study (De Koster 2006).

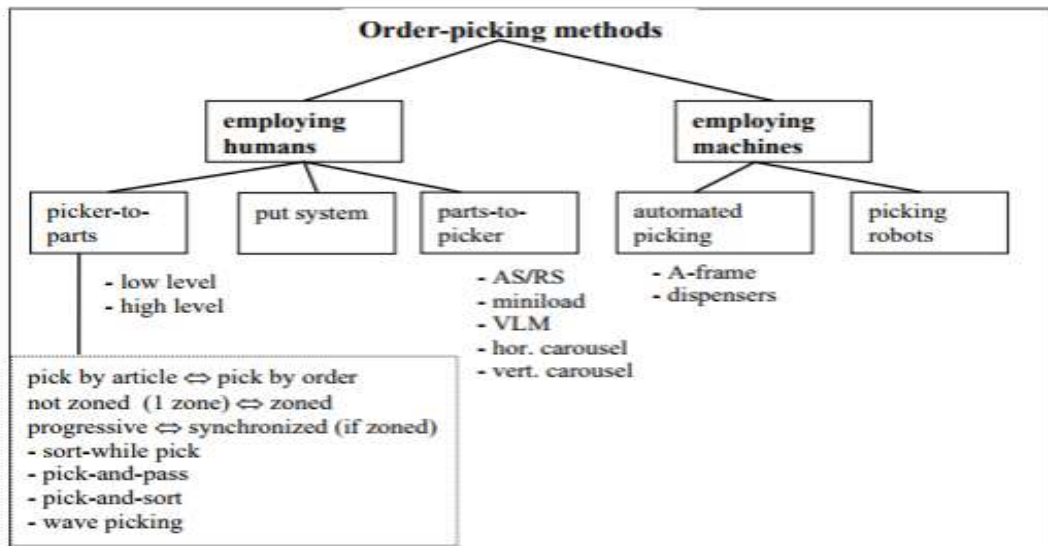


Figure 2-5. Classification of order-picking systems (based on De Koster 2006)

2.4. Warehouse performance

Warehouse performance is measured by warehouse key performance indicators (KPI). Such KPIs can be; productivity, shipping accuracy, inventory accuracy, dock-to-stock time, warehouse order cycle time, storage density, and level of automation (Frazelle 2002).

In order to measure the impact of a successful order picking strategy relevant indicators need to be defined. According to Cristopher lead time and fulfilment cycle are the basic measurements and performance indicators. Order fulfilment cycle is defined as the time period between the moment order received by the warehouse to the point when goods being delivered at the customer request (Cristopher 2005).

As said above picking is both the more cost-intensive warehouse activity as well as being considered having the largest potential for improving order fulfilment cycle. Minimizing of the order picking is often a good place to start the overall effort to improve warehousing efficiency and customer satisfaction since it can be arranged without heavy capital investments (Cristopher 2005).

According to Le-Duc * and De Koster (2005), the performance and efficiency of the order picking affected by these factors:

- ✓ The demand patterns
- ✓ The configuration of the warehouse
- ✓ The storage strategy, how to allocate SKUs within the warehouse
- ✓ The batching method: how to group orders and divide order among picker
- ✓ The routing and sorting, how to determine the SKUs to be picked and how to consolidate

2.5. Picking improvement policies

As described in the number of different works of Goetschalckx, De Koster, Jacobs, Frazelle, Meller and Tompkins, there are commonly three strategies used to improve order picking:

- Assigning items to storage locations (tactical and operational level)
- Order picker routing (routing) (operational level)
- Grouping or batching all picks of the orders (batching) (operational level)

Storage allocation strategies and zoning strategies determine where to store the items to reduce material handling cost. Routing, batching and order release mode, on the other hand, determine the best sequence and route of the locations for storing and picking a set of items (De Koster 2007). As stated in the limitation part routing and batching algorithms will be out of the scope of this study.

In order to describe the main factors affecting three main approaches for order picking optimization, Adil introduced wheel of order picking, as shown in Figure 2-6. The wheel is furthermore affected by physical attributes, like the warehouse design, the equipment used, as well as the information flows, like forecasting and warehouse management system. The information flow is needed in several ways to coordinate the flow of materials and provide the data about storage capacity, sales forecasts, and the information about items.



Figure 2-6. Wheel of the order picking. Factors affecting picking policies (Adil, 2008).

2.6. Storage assignment policies

Storage assignment is concerned with allocation of items to storage locations within the storage area. De Koster et al. define the storage assigning as, the set of rules which can be used to assign the incoming products to the storage locations in the storage zones. Correct storage allocation helps in the reduction of material handling costs and the improvement of space utilization (De Koster et al. 2007). According to Goetschalckx et al., a storage assignment policy is a set of rules which determine the warehouse allocation for different items finding the optimal locator to minimize the average travel and picking time required (Goetschalckx et al. 1990).

In the literature, different policies – i.e., general concepts – for storage assignment are considered. Most important allocation policies are described next. Popularity-based allocation suggested by Heskett, dedicated, random and class-based storage were introduced by Graves et al in 1976. Family grouping policy is newer and has gathered lots of attention in the literature during the last years. As assignment is a special case of transportation problem solved using transportation model in order to find the minimum cost, time or distance.

2.6.1. Random assignment

De Koster et al. define random allocation as a “closest open location storage” strategy in which the first vacant location found by an employee during the warehouse inbounds becomes a potential candidate location for the incoming items (De Koster 2007). According to Petersen et al., the main principle of random storage is to allocate all incoming items randomly, by choosing from all the obtainable locations with the identical probability randomly. The random locator assignment strategy would only function in a warehouse run by an automated WMS to keep track of the locations assigned to each item. Otherwise, the search-time of the items during the retrieval process would be seriously affected (Petersen et al. 1997).

2.6.2. Dedicated assignment

According to De Koster, dedicated storage is assignment of items to a fixed, exclusive storage location or set of locations. A drawback of the dedicated storage is that the locations are reserved even for items that are not currently in stock. Furthermore, for each item adequate space must be reserved such that the maximum potential inventory level can be placed. Consequently, the space utilization is the lowest among all allocation strategies leading to the high warehouse rent costs for LSPs (De Koster 2007). A benefit of dedicated storage, especially before automated WMS, is that order pickers become familiar with the location of the items, which may speed up retrieval (Gu et al. 2010).

2.6.3. Class-based assignment

De Koster et al. describe the concept of the class-based allocation, as combination of random and dedicated allocation strategies. The idea behind, is to division the inventory items into classes. Each class would have an allocated zone, where any space available within the class is randomly used by the items fitting to that class. Classification related to the work of Italian sociologist and economist Vilfredo Pareto “85% of the wealth of the world is held by 15% of the people”. In the scope of storage allocation, the main principle for classification is that the more frequently demanded class covers only about 15% of the items kept in warehouse but contributes to about 85% of the turnover. More frequently demanded items are commonly defined as A-class items, correlated for 80 % of the picking frequency; items with moderate relevance as B-class items, correlated for 15 % of the picking frequency; less frequently requested items as C-class, correlated for 5 % of the picking frequency (Cheng 2010).

2.6.4. Affinity-based (family grouping) assignment

Lynn et al. define two items as correlated, similar or affine if they are frequently demanded together, for instance in the same customer order or within the same time period. In warehousing affinity described as the probability that pairs of items will occur in the same order or batch (Lynn et al. 1976). According to De Koster et al., the affinity-based allocation is the unique in considering the potential connection between the items. For instance, certain item can be frequently demanded together with another item. In this situation, it may be practical to keep these two items next to each other (De Koster et al. 2007).

2.6.5. Popularity- based assignment

Originally Heskett defined popularity-based policy, as distributing items over the warehouse storage zone corresponding to their turnover, as the only definition of popularity. The items with the largest sales volumes are placed at the most reachable locations, typically next to the packing and shipping area. Items with the low demand are assigned somewhere towards the back of the storage (Heskett 1964). Hausman defined inventory turnover as the cost of items sold divided by the average inventory level. Turnover frequency is calculated as the amount picking requests per time period. On the other hand, frequency demonstrates the average storage time per item. Once warehouse specific criteria for popularity are defined, items are ranked and allocated to warehouse zones in descending order, with the most desirable locations reserved for the most popular items (Hausman et al. 1976).

2.6.6. Cube per order index (COI) assignment

This classification takes into attention both the picking frequency and warehouse space utilization. Items are categorized by the increasing index value and the groups with the lowest value are placed in the most easily accessible positions (Goetschalckx et al. 2007). Originally introduced by Heskett in 1963 the Cube-per-Order Index (COI) defined as the ratio of the item's total space requirement to amount of picking tours required in accordance with customer demand. The original heuristic involved placing the items with the lowest COI value next to packing zone, allocating items that combined a high demand frequency with a low space requirement in the most desirable locations. Items were then allocated progressively starting from the packing zone by increasing the COI. This approach is extensively studied by Heskett et al., 1963, Francis et al 1967, Harmatuck 1977, Bhaskaran, 1988.

2.6.7. Hungarian assignment

The Hungarian method of assignment provides us with an efficient means of finding the optimal solution. The Hungarian method is based upon the following principles:

- (i) If a constant is added to every element of a row and/or column of the cost matrix of an assignment problem the resulting assignment problem has the same optimum solution as the original problem or vice versa.
- (ii) The solution having zero total cost is considered as optimum solution.

Based on the Hungarian methods, the followings steps are utilized to implement the assignment method.

1. Subtract the smallest number in each row from every number in the row. This is called a row reduction. Enter the results in a new table.
2. Subtract the smallest number in each column of the new table from every number in the column. This is called a column reduction. Enter the results in another table
3. Test whether an optimum assignment can be made. We do this by determining the minimum number of lines (horizontal or vertical) needed to cross out (cover) all zeros. If the number of lines equals the number of rows, an optimum assignment is possible. In that case, go to step 6. Otherwise go on to step 4.
4. If the number of lines is less than the number of rows, modify the table in this way:
 - a) Subtract the smallest uncovered number from every uncovered number in the table.
 - b) Add the smallest uncovered number to the numbers at intersections of cross-out lines
 - c) Carry over numbers crossed out but not at intersections of cross-out lines carry over to the next table
5. Repeat steps 3 and 4 until an optimal table is obtained.
6. Make the assignments. Begin with rows or columns with only one zero. Match items that have zeros, using only one match for each row and each column. Eliminate both the row and the column after the match.

This will be used when the rows and columns are small in number. But for large number of rows and columns software packages are more appropriate.

In the Table 2-1 related works in the field of the assignment policies are summarized.

Table 2-1. Studies on the assignment policies

Storage allocation strategy	Related researches
Random	Hausman et al. (1976), Malmborg (1996), Larson et al. (1997), Pettersen (1999), Van den Berg (1999). De Koster et al. (2007), Roodbergen (2007), Chan (2011)
Dedicated	Goetschalckx and Ratliff (1990), Cormier et al. (1992), March et al. (1997), Elsayed (2005), De Koster et al. (2007), Chan (2011)
Class-based (ABC)	Hausman et al. (1976), Frazelle (1989), Cavinato (1990), Cormier et al. (1992), March, et al. (1997), Mahan et al. (2003) Le-Duc et al. (2005), De Koster et al. (2007) Goetschalckx (2007), Chan (2011)
Affinity-based,- Family grouping	Kallina and Lynn (1976), Rosenblatt (1989), Frazelle (1989), Schuur (2006), Smith et al., Heragu (2009), Pitzer (2010)
Popularity-based (COI)	Heskett (1963), Kallina and Lynn (1976), Bhaskaran (1996), Schmenner et al. (1999), Aase et al. (2004), De Koster (2007), Goetschalckx (2007)

Based on the literature review the main assignment policies and respective benefits and drawbacks are summarized in the table below.

Table 2-2. Assignment policies and respective benefits and drawbacks

Allocation strategy	Definition	Benefits / Drawbacks
Random	Assigns storage locations based on the first come first served basis, and the available space	<p>Benefits</p> <ul style="list-style-type: none"> - results in a high space utilization - easy to implement, balanced picker traffic <p>Drawbacks</p> <ul style="list-style-type: none"> - increased travel distance over other policies - only functions in a WMS controlled environment - material handling cost is frequently greater
Dedicated	Fixed storage location(s) per product	<p>Benefits</p> <ul style="list-style-type: none"> - low-tech, easy to implement, pickers can memorize locations - typically reduces the material handling costs <p>Drawbacks</p> <ul style="list-style-type: none"> - low storage utilisation
Class-based (ABC)	Inventory is assigned a class based on some criteria (demand, value, size). Each class is assigned a zone of storage locations	<p>Benefits</p> <ul style="list-style-type: none"> - Uses the benefits of both random and dedicated storage - less congestion if used within class <p>Drawbacks</p> <ul style="list-style-type: none"> - Periodic demand review required - only reduces average tour length - Warehouse resulting in a large amount of reshuffling of stock.
Affinity-based Family grouping	Place parts, which are often ordered together, close to each other	<p>Benefits</p> <ul style="list-style-type: none"> - shorter picker tours, higher throughput <p>Drawbacks</p> <ul style="list-style-type: none"> - congestion issues and algorithm parameter tuning
Popularity- based (COI)	Locations, position heavy and fast moving products in accessible locations	<p>Benefits</p> <ul style="list-style-type: none"> - Reduction in travel time and distance - easy to implement, optimal under certain conditions <p>Drawbacks</p> <ul style="list-style-type: none"> - Aisle congestion - Unbalanced utilization of the warehouse

2.7. Lean warehousing

Mayerson (2012), defines as Lean warehousing is a combination of terms i.e. lean and warehousing where as lean is a philosophy, a concept, an approach or a way of thinking that helps to shorten the total lead time, improve efficiency, reduce the cost of operations and enhance the productivity of the system. Lean system is all about removing any waste that from processes to make it more efficient. Waste is all that the end customer is not willing to pay for (Voehl, et al., 2014). Perfect lean operating model would have no traveling time, no storages and no waiting time (Voehl, et al., 2014). The lean ideas and tools are generic in nature, therefore it can be implemented in multiple situations and working environments e.g. manufacturing, services, supply chain management or warehousing etc. The adoption of lean tools in a particular organization or working environment can be done under certain theoretical and practical guidelines that help to understand and implement the fundamental, operational and organizational changes in the system. Myerson highlighted that most of the lean tool concepts can be applied to warehouses, such as 5S, value stream mapping (VSM), six-sigma (DMAIC), team building, kaizen, problem solving and error proofing, kanbans systems, line balancing and general waste reduction (Mayerson, et al., 2012).

2.7.1. DMAIC model

According to Prashar (2013); Mehrjerdi (2011), DMAIC (Define-Measure-Analyze-Improve-Control) is process improvement method and tools help to analyze and improve existing business processes. This can result in cost reduction, elimination of defects, improved customer satisfaction, improved cycle time, increased profitability, improvements in on-time delivery, logistics improvement, sales forecasting ability and improved quality of customer service. The methodology is not only used in manufacturing but also in services and in retail businesses (Kumar, Strandlund, & Thomas, 2008).

2.7.2. The approach “5s”

5S is a Lean approach which is about creating a standard in the business. It is a good start for businesses who want to invest in Lean thinking since it is a basic requirement for well organized activities and a requirement before being able to identify waste. This approach includes: sort, set in order, systematic cleaning, standardize, self-discipline (Pettersson et al. 2009).

2.8. Waste

All non-value adding activities or processes are considered as waste. It is, all that the end customer is not willing to pay for (Voehl, et al., 2014). Wastes divided into seven categories of activities which are listed below (Petersson et al. 2009).

1. **Overproduction-** producing too much or too soon.
2. **Defects-** frequent errors in paperwork, product quality problems, or poor delivery performance.
3. **Inappropriate processing-** excessive storage and delay of information or products.
4. **Unnecessary inventory-** takes place when any stage of the process is done twice instead of one.
5. **Excessive transportation-** excessive movement of people, information or goods resulting in wasted time, effort and cost.
6. **Motion-** poor workplace organization includes back and forth movement in a workplace and searching for parts or tools.
7. **Waiting-** long periods of inactivity for people, information or goods, resulting in poor flow and long lead times.

2.9. Definition of terms

Warehouse: is a facility in the supply chain to consolidate products to reduce transportation cost, achieve, economies of scale in manufacturing or purchasing or provide value added processes and shorten response time (A, N. Subramanya and M. Rangaswamy, 2012).

Performance: is the accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed (businessdictionary.com, 2018).

Order picking: is a warehouse function dealing with the retrieval of items from their storage location in order to satisfy a given demand specified by the customer requests (Henn et al, 2013).

Lean: is a philosophy that incorporates a set of tools and techniques into business processes to accomplish waste reduction due to optimization of time, human resources, assets and productivity, while improving quality levels on products or services (Womack and Jones, 2003).

2.10. Research Gap

According to Tompkins et al., there is a gap between reality and academic research, when it comes to the order picking policies. Not all new picking policies have been studied sufficiently. There is still a shortage of case studies that consider the optimal combination of warehouse design, storage assignment, order batching and routing (Tompkins et al. 2010). While there have been several investigations on the general order picking problem, little research regarding order picking for a healthcare warehouses was found. However, due to the increasing fluctuation in the demand, allocation policy needed to be reviewed and adjusted over time for the reasonable utilization of warehouse space. Since the main goal of this thesis is to minimize overall order pick time in warehouse of Ethiopian pharmaceutical supply agency. Proper storage of Pharmaceuticals and Medical Supplies ensures their safety, efficacy, stability and quality; this can be achieved partially by storing Pharmaceuticals and Medical Supplies according to their specific storage condition separate from other non-Pharmaceuticals and Medical Supplies.

CHAPTER THREE

3. Materials and Methods

Research methodology is a way to solve the research problem systematically. It is a science of studying how research is done scientifically (Kothari, 2004) and, in which one can study the various steps that are generally adopted by researcher in studying research problems along with the logic behind them. Therefore, the main purpose of the research methodology is to explain how the research was accomplished, what knowledge was required, what information was needed & how it was collected analyzed. This section presents the methodology used to achieve the objectives of the study. It is also, covered descriptions of the study area, research design, study subject, types of data, data collection techniques, methods of data processing and analysis approach employed to this study. In general, this part describes the systematic and appropriate scientific methodological aspects.

3.1. Description of the study area

This studies focused on performance improvement of warehouse order picking process in Ethiopian Pharmaceuticals Supply Agency (EPSA), Arbaminch branch distribution center which was established in September 2008 by proclamation No. 533/2008 as part of Pharmaceutical Logistic Master Plan implementation under the law of the Federal Democratic Republic of Ethiopia Government. The main aim of the warehouse is to serve the health facilities of Arbamich and surrounding regions. So according to the request from the health facilities the agency buys Pharmaceuticals and Medical Supplies from head office Adiss Ababa branch. All the Pharmaceuticals and Medical Supplies bought from the suppliers stated before are stored in the warehouses the agency specified for this purpose until the facilities come and take their share. As a result warehouses are playing a pivotal role in the agency as the agency itself is a big participator in the logistic and supply management of Pharmaceuticals and Medical Supplies at arbaminch and around region. So improving performance of picking process in the warehouses is very significant in relation with the fact that these warehouses are main sources of Pharmaceuticals and Medical Supplies for prevention or treatment of diseases in arbaminch and around regions.

3.1. Research approach

For this particular study the researcher used both the Quantitative and Qualitative research approaches, focusing more on quantitative approach. Quantitative research approach is a means for testing objective theories by examining the relationship among variables (Creswell, 2008). Qualitative research methods focus on discovering and understanding the experiences, perspectives, and thoughts of participants. It is usually described as allowing a detailed exploration of a topic of interest in which information is collected by a researcher through case studies, ethnographic work, interviews and so on (Michel R. Harwell, 2011).

3.2. Research design

The research of this work is conducted as a Case study. According to Schirmer, a case study is a popular research method in the warehousing area, with the purpose to investigate specific problems within the limitation of definite conditions, circumstances, or processes. Benefits of the case study method include data collection and assessment within the scope of the process, integration of qualitative and quantitative data in the evaluation process, and the potential to cover comprehensive real-life states. This way the process can be examined on the micro level (Schmenner 1997 p. 420).

This thesis design based on the DMAIC model (Smith, 1986). DMAIC is a tool that allows a company to Define and learn its current process, Measure performances of the process, Analyze strengths, weaknesses, opportunities and threats of the process to identify the root causes of problem and provide a solution to reduce/eliminate them.. It is important to improve the current process by implementing the newly invented or modified process and exercise control to ensure the sustainability of the process. It is not only used in manufacturing but also in services and in retail businesses (Kumar, Strandlund, & Thomas, 2008). DMAIC is an acronym for the five components: Define, Measure, Analyses, Improve and Control and a new stage called structured literature review is added, so the model consists of 6 stages.

Stage 0 - Structured Literature Review

In this stage, reviews that uses systematic and explicit methods clearly identify, select, collect, and critically consider.

Stage 1 - Define

Antony, Bhuller, Kumar, Mindibil, and Montgomery (2012) stated that this phase is used to define the goals, scope, and business process requirements. It uses customer data and feedback to determine problems. Using DMAIC methodology can help the researcher to identify the root causes encountered when the researcher asks targeted questions.

Stage 2 - Measure

This phase uses collected data to map the current process and capture how the process is measured (Measure Phase, n.d., para 1). Information must be studied and fully understood to determine not only how the processes work but how well they perform (Wiesenfelder, 2011).

Stage 3 - Analyses

The objective of the Analyze phase is to identify potential root causes. This step is also used to identify and isolate the major causes for which improvements will be formulated. The step is used to help resolve the root causes by analyzing the problems using the data that has been collected in prior phases (Wiesenfelder, 2011). During this stage, the researcher is able to analyze the collected information and identify potential and actual root causes of the problems. The conclusions reached during this phase are used during the next step, Improve, to find possible solutions to eliminate or mitigate and develop preventive processes so that the same problems do not recur.

Stage 4 - Improve

The main objectives of this phase are to propose solutions to identified root causes, to evaluate the proposed solutions, to select the best solutions and to implement them (Cheshmberah & Nabavi, 2014). Beady (2005) and Pande, Neuman, & Cavanagh (2002) recommend that “Thinking outside the box” will generate creative ideas and solutions and/or eliminate ideas and solutions that are not applicable. Once solutions are selected, a pilot test should be conducted to observe how well each works, what works well and what needs modifications to improve the efficiency and effectiveness (Beady, 2005). During the pilot test, more data is collected as additional information to support the full implementation.

Stage 5 - Control

The objective of DMAIC is not only to eliminate the weaknesses and the improve process but also to control the process so that it continues running well in the long term (Mishra & Sharma, 2014). The major aim of the Control phase is to standardize, monitor and integrate changes after implementation (Antony et al., 2012).



Figure 3-1. Research design

3.3. Data collection methods

Data is the means by which we present our findings in a research. Without which our research can be a waste of time (Salkind, 2010). The data used for this research work can be collected from several sources. This collected data can be basically divided into two different types, primary and secondary data (Kumar, 2005). Primary data are both qualitative which including observation and interview and quantitative data, organized by monitoring the time warehouse outbound team is spending on the different stages of picking process at a warehouse. Secondary sources of the data were from the related researches conducted previously and from historical database which are used to enrich the study.

3.4. Population, Sample and Sampling techniques

The study area, as stated earlier was organization's warehouses where the staffs that have participated in the study are small in number. As the research itself focuses on order picking process improvement, from the whole employees and stakeholders of warehouse, the target population of this study are employees who are working closely to order picking section. However, from the total number of fourteen (14) order picking operators of the agency, the target population of this study consists of six (6) pickers who are randomly selected by the researcher in collaboration with warehouse managers. The selection criteria of these operators are mainly based on there working experience.

3.5. Method of data analysis

Data analysis is one of the essential parts of a research, as it is the data analysis that tells the output of the research we are working on. When working on data analysis a researcher should try not to be biased on what he/she is working on. Having this at hand the data of this study was analyzed and interpreted using Microsoft Excel, Cause-and-Effect Analysis and Pareto Chart Analysis, POM-QM software. All these tools were used to identify the problems, areas for improvement and solutions to improve the order picking process.

- ✓ **EXCEL**:- It is the number one platform when it comes to analyzing data, finding information, preparing charts, and presenting them for comparing the exist and proposed system with their result
- ✓ **Cause and Effect analysis (fishbone diagram)**:- by using cause and effect analysis to identify the root and the major causes of these problems so that they can ahead for solution making.
- ✓ **Pareto analysis**: - by using Pareto analysis, the major/the vital few problems that causes most of the effect on the system breakdown are identified and will be analyzed.
- ✓ **POM-QM software**: - a software that used for optimization of transportation (allocation) problems. It optimizes the total pick lead time and distance in picking process.

3.5.1. Measurement tools

- ✓ **Meter**: - used to measure pick distance from I/O (dispatch area) to each pick locations.
- ✓ **Stopwatch**: - used to measure evaluate pick time of each picker's in picking process.

3.6. Methodological framework

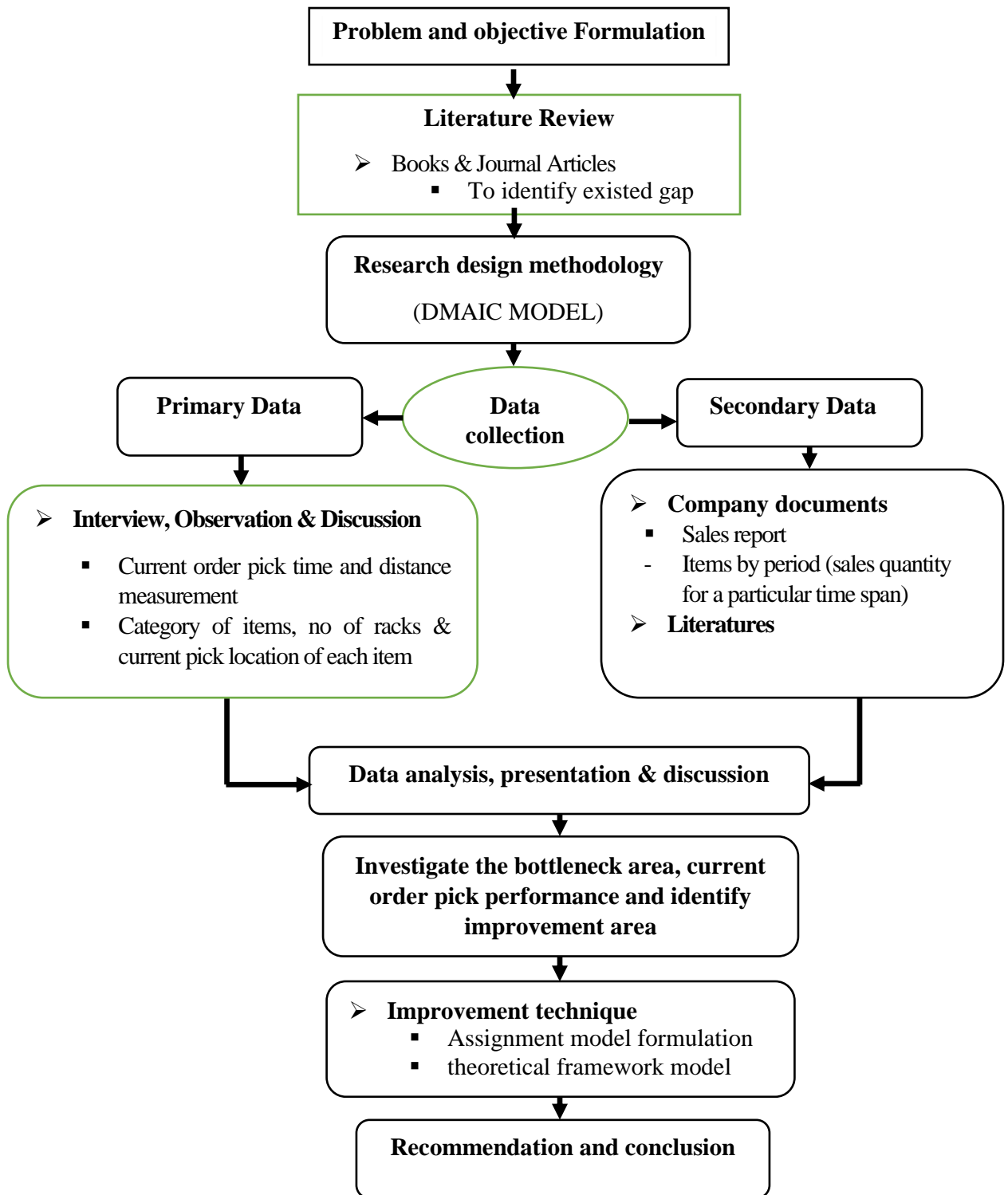


Figure 3-2. Methodological framework

CHAPTER FOUR

4. Result and Discussion

4.1. Introduction

This research was designed to improve the performance of warehouses order-picking process in Ethiopian pharmaceutical supply agency by minimizing overall order pick time. It focuses on “What are the root causes of delays in the order picking process and how can the time used to provide this service to customer be reduced?” This section focuses on the use of tools and methodology of DMAIC, consisting of Interviewing, Observation, Cause-and-Effect Analysis, and Pareto Chart Analysis.

4.2. Current state analysis

In this research, there are no products to be followed, but pickers in the picking process. The pickers' time, in this case, is the value and waste is what stops them from using their time right. To find what prevents the pickers from using their time right, the picking process will be analyzed in this section by describing the current state of the studied order picking process. This state of this study is crucial, as it describes the strengths and weaknesses of the current process. The following Data was collected both from direct observation, interviews and from evaluation of the time spending on the different stages of order picking process to register the situation in the warehouse.

4.2.1. Materials handling process

In the agency warehouse, materials handling process can be classified into four main activity groups: receiving, inbound, order picking, and outbound. The incoming flow of the order cycle begins with the arrival of the direct shipments from head office. In accordance with the agreed logistics procedure and transportation mode, the direct deliveries are unloaded by inbound staff of the warehouse. As soon as the goods have been unloaded, packages are quickly examined for physical damages and any possible inconsistency compared to customer order, as a rule, internal sides of the boxes cannot be examined directly during receiving due to the time restriction, as well as the consistency of the items inside the packages cannot be verified. In case no any issues appear, warehouse inbound team sign and receive related shipping documents, special cases for the inconsistency of box content are handled separately between parties and accepting the accountability for any damage on the package level later. Below figure indicate the flow of commodities and information in EPSA arbaminch.

The Flow of Commodities and information in EPSA arbaminch

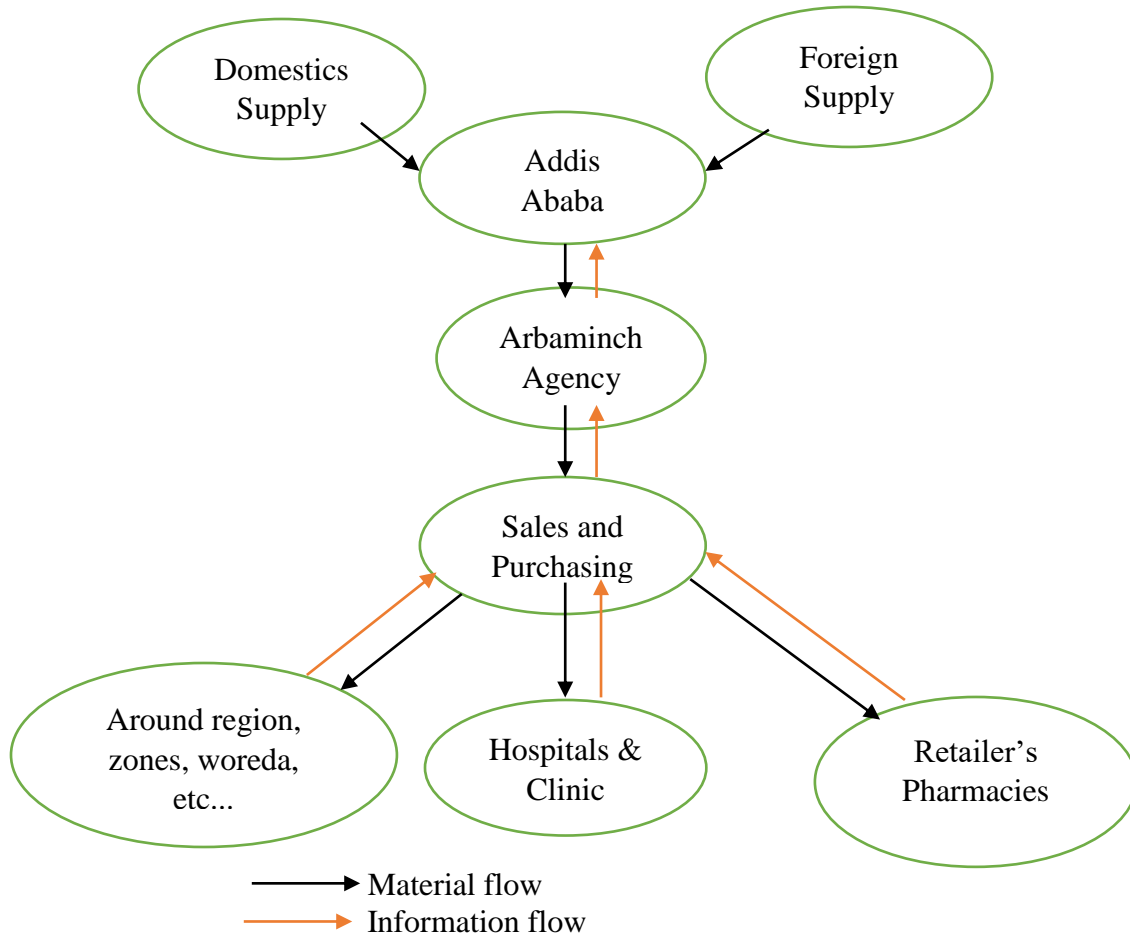


Figure 4-1. The flow of commodities and information in EPSA,arbaminche

4.2.2. Status of order picking process

Outbound part of the outgoing flow starts with the order picking process, the agency uses manual or “man-to-goods”, picking strategy. When specific items are demanded for the new sales order, sales department arranges sales data, delivery note and create picking list, which is handed over to the warehouse outbound team. The first thing that the outbound team member does is to; see all orders in their zone for the day. The orders are listed in the order they are being shipped, when the picker has chosen what order to pick the next step is moves to the first storage location in the picking list, pick up the demand amount of items, and continue to the next location. As soon as all required items are picked successfully, they are return to I/O Typically picking order can be completed in the single picking tour.

After all, items have been checked as being picked, the team notify to transportation section to collect packed shipment from the loading zone. As soon as these activities are completed, items are moved to where they are going away to the final destination. Below figure indicates all the moments during one picking round that was captured by observation is shown.

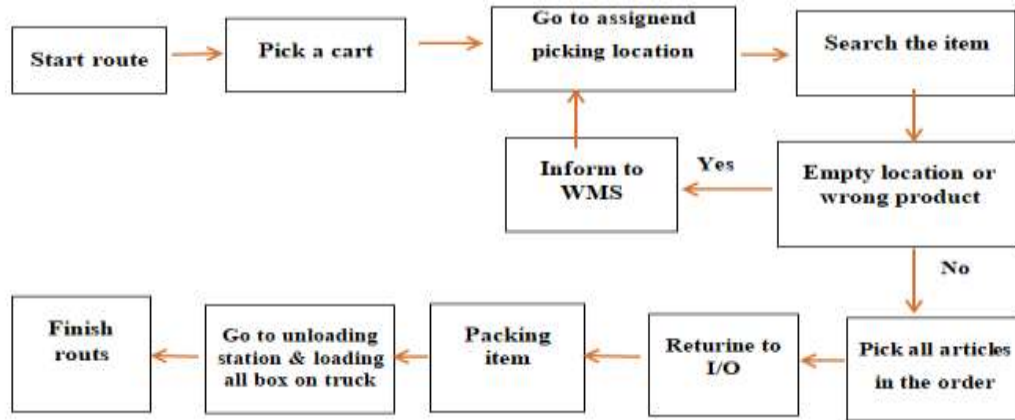


Figure 4-2. Activates in order picking process

4.2.3. Warehouse design

The layout of agency warehouse is U-shape warehouse with single inbound and outbound zone placed in the front of the warehouse next to unloading and loading gates. The warehouse includes 2540 pick locations with five different levels, starting from the floor level: A, B, C, D, and E. Due to pharmaceutical nature of the component they stop to store on floor level; E. To present the time spent of retrieval of items from the higher levels, each additional level increases conditionally picking distance by one and half meters, compared to retrieval from the same place level A. Each Storage locations are identical in height, width and length with twenty three (23) total number of Rack in the warehouse.

In the warehouse, the pick location of fast moving pharmaceutical product starting from rack- X,W,V,U,T&S (rack X-1-A-E to rack-S-22-A-E). Intermediate(moderate) moving pharmaceutical products starting from rack- R, Q, P, N, M&L (rack-R-1-A-E to rack-L-24-A-E). Bulk (Slow moving pharmaceutical product starting from rack- K,J,H,G,F,E,&D (rack-K-1-A-E to rack-D-28-A-E). Expired and quarantine pharmaceutical product starting from rack- C-B&A (from rack-C-1-A-E to rack A-30-A-E). Chemicals & dangerous pharmaceutical products starting from, rack-Y-1-A-E to rack-Y-4-A-E.

Below figure shows the layout of the agency warehouse and total number of pallet location in warehouse.

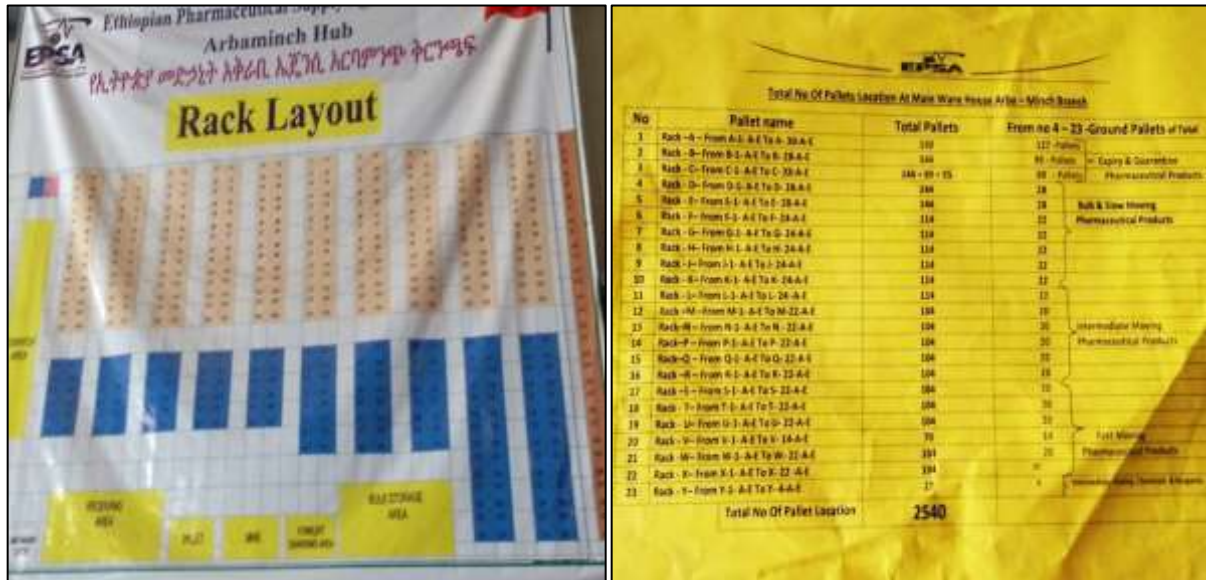


Figure 4-3. Layout and pallet location

4.2.4. Quality of tools

The lack of enough quality of picks aid material makes the pickers cautious and slowing them down more than necessary, which wastes time. In the agency, there is lack of enough pick aid materials, such as Cart, forklift, ladder and etc. Pickers use the ladder, with a small ladder step up on to be able to reach the highest picking locations, level D and E. if ladder is unstable; it contributes to a higher risk of dropping the items. When there is a high demand of products, this issue creates a higher pressure on the picker to work as fast as desirable. Also every day the warehouse management team gives a zone to pickers to pick in, which makes them unfamiliar with piking items and picks line. This might affect the customer service, which is not beneficial from a bigger perspective of the agency. As I told in limitation part, possible changes in layout design of the warehouse or picking tools will not be considered, as it need high budget cost.



Figure 4-4. Storage of products in the agency warehouse

4.3. Demographic information of participants

This section describes the main stakeholders within the order picking process of the company. However, it is important to consider stakeholders outside the order picking process as well, who might experience differences in the way orders are picked. The stakeholders of the research and the motivation for their interest are described in the table below.

Table 4-1. Stakeholders of the research

Stakeholder	Motivation
Management team	The management team of the company desires a new strategy for the products of an order to be picked.
Warehouse manager	The warehouse manager of the company has a medium-high interest in the final solution. Eventually, he will have to know how the system will work out and what the critical elements are related to the situation as it is beforehand
Order pickers	The order pickers are the warehouse employees which eventually pick the different products which complete an order.
Customer	An order picking process will not start without the desire of a customer for some specific product(s). Therefore, the customer should be mentioned as an important stakeholder as well. The customers provide the main rewards for the company. In terms of money, but also, for example, in promotion. When a customer experiences a good delivery of desired products, there is a better chance that a customer recommends the services of the company to another potential customer.

As the research itself focuses on order picking process improvement, from the whole employees and stakeholders of warehouse, the target population of this study consists employees who are working closely to order picking process of warehouse section. However, from the total number of fourteen (14) order picking operatives of the agency, the target population of this study consists of six (6) pickers who are working closely to the warehouse order picking section.

Table 4-2. Working positions of operatives

	Frequency	Percent	Valid Percent	Percent Cumulative
Valid Warehouse pickers	11	78.6	78.6	78.6
Dispatchers	3	21.6	21.6	100.0
Total	14	100.0	100.0	

Considering the current position, the warehouse pickers registering 11(78.6%), followed by dispatch officer with frequency of 3(21.6%). Therefore, the researcher believed that the time taken by the participants reflect the overall order picking time of the agency.

Table 4-3. Experience of operatives

	Frequency	Percent	Valid Percent	Percent Cumulative
Valid <one year	5	35.7	50.0	35.7
1-5 year	7	50.0	35.7	85.7
>5 year	2	14.3	14.3	100.0
Total	14	100.0	100.0	

As the above table illustrates with regard to the year of service for the participants, the first rank is taken by those participant with service year of 1-5 years with the frequency of 7 (50.0%), followed by those having the service year of below one year and those with the service year of greater than 5 years with the frequency of 5(35.7%) and 2(14.3).

Table 4-4. Educational level of operatives

	Frequency	Percent	Valid Percent	Percent Cumulative
Certificate	11	78.6	78.6	78.6
Diploma	2	14.3	14.3	92.9
Valid BSc/BA Degree	1	7.1	7.1	100.0
Total	14	100.0	100.0	

As the above table 4-4 indicates, educational status of the respondents, the first category in number was taken by those who have educational background of certificate and account for 11 (78.6%), followed by those who having college diploma 2 (14.3%). The remaining are those with university degree having frequency of 1 (7.1%) respectively.

4.4. Order pick time and distance analysis

The status of order picking practice in the warehouses of the agency can be answered by the empirical data collected from the historical database obtain from the warehouse IT Department. Additionally, the evaluation of the picking process is organized by monitoring the time warehouse outbound team (pickers) is spending on the different stages of order picking process by using stopwatch. Order picking time which can be measured by the four activities of the order picking process; the first is the travel time required for the picker to reach the pick point, second, the search time required for the products to be found, third, the retrieval time required for the products to be retrieved, and fourth, the return time required for the picker to transport the product to the order point.

Currently there were 210 different pharmaceutical product stored in warehouse of the agency. Due to inability to cover all, I the researcher focused only on A-Class (fast mover) items. Let's analyse the where these items were located and the order picking time and distance in order to pick them in a single order. Order picking time and distance can be calculated by adding each walking time or distance from the gate (dispatch area) of the warehouse until the order picker return to the exit by moving across the rack where the intended item is stored. The case company "KPI (key performance indicator)" shows the average picking time per line item was 1.14 minutes (EPSA, 2022).

4.4.1. EPSA Arbaminch warehouse detail

- ✓ **Total pick location** =2540 (from Rack A-1-A-E to Rack Y-4-A-E)
- ✓ **Total rack** = 23
- ✓ **Rack level** = A,B,C,D,&E = 5
- ✓ **Rack length distance** (each Rack A to Rack E) =1.25 meter*4= **5meter** height
- ✓ **Average picking time** (per line item) = **1.14 minutes** (KPI)
- ✓ **Total pickers** = 11
- ✓ **Total dispatchers**= 3
- ✓ **The number of selected A-Class (fast mover) items** = 17 items

4.4.2. EPSA Arbaminch pick location detail

- ✓ **Fast moving** pharmaceutical product starting from Rack- X, W, V, U, T&S from (Rack X-1-A-E to Rack-S-22-A-E).
- ✓ **Intermediate (moderate) moving** pharmaceutical products starting from Rack - R, Q, P, N, M&L from (rack-R-1-A-E to rack-L-24-A-E).
- ✓ **Bulk (Slow moving** pharmaceutical product starting from Rack - K, J, H, G, F, E, &D from (rack-K-1-A-E to rack-D-28-A-E).
- ✓ **Expired and Quarantine pharmaceutical product** starting from rack-C-B&A (from rack-C-1-A-E to rack A-30-A-E).
- ✓ **Chemicals& Dangerous pharmaceutical products** starting from Rack-Y-1-A-E to Rack-Y-4-A-E.

4.4.3. EPSA Arbaminch order picking process detail

- Moments during one picking round that was captured by observation:-
 - ✓ **Stage1-** Receives pick list
 - ✓ **Stage2-** Start root
 - ✓ **Stage 3-** Pick up trolley (cart)
 - ✓ **Stage 4-** Travel to assigned pick location
 - ✓ **Stage 5-** Search the items (if empty location or wrong product go back and inform to warehouse management and start root from beginning. If correct, proceed to next stage
 - ✓ **Stage 6-** Pickup (retrieve) goods
 - ✓ **Stage 7-** Return to dispatch area (I/O)
 - ✓ **Stage 8-** Checking item
 - ✓ **Stage 9-** Loading items
 - ✓ **Stage 10-** Finish root (customers receive products)

4.5. Order pick distance analysis

Table 4-5. Total distance travelled to issue selected A- class items

#No	Item Name	Current Pick Location	Distance (m)
1	Paracetamol- 250Mg, 500 Mg TAB	E-15-A-E	68.6
2	Glucose- 10%&50%(hypertonic)	M-14-A-E	32.2
3	Amoxicillin- 250Mg, 500Mg Cap	D-21-A-E	74.8
4	Tetracyclin- 1% Eye Ointment	S-17-A-E	23.2
5	Tinidazole- 250Mg, 500MG TAB	X-7-A-E	9.2
6	Albendazole- 250Mg, 500Mg TAB	H-14-A-E	42.2
7	Doxycycline-250Mg,500Mg/5 ml	U-13-A-E	18.6
8	Mebendazole-100 Mg; 500 Mg TAB	K-18-A-E	33.4
9	Cloxacillin- 500Mg injection	J-16-A-E	23.2
10	Ceftriaxone-250,500Mg/1Gg-PF	L-2-A-E	27.4
11	Azithromycin*-250,500 Mg TAB	R-12-A-E	16.8
12	Ciprofloxacin-250,500Mg TAB	T-11-A-E	27.4
13	Hydrocortisone-100Mg	G-8-A-E	46.6
14	Ibuprofen-200mg/5ML.	Q-22-A-E	13.6
15	Benzylpenicillin-600MgTAB	F-22-A-E	57.2
16	Metronidazole-250,500 Mg in 100-ml	W-8-A-E	16.8
17	Cefalexin-125 Mg/5ml;250 mg/5 ml	V-9-A-E	13.6
Total distance travelled			544.8m

Source: Own survey & Company's data, 2022

Order picking travel distance can be calculated by adding each walking distance from the gate (dispatch area) of the warehouse until the order picker return to the exit by moving across the intended item is stored. As the results of the measurement series indicates, total distance travelled to pick those items from dispatch area is 544.8 meter and the average travel distance in a single order tour is 32 meter.

4.6. Order pick time analysis

To justify efficiency gain in reducing picking time, the researcher with EPSA Arbaminch branch management team selected 17-A-Class (fast mover combined pharmaceutical products) based on their order frequency and popularity and measured the time taken to reach those selected item until finishing the route in a single order tour using stopwatch.

Table 4-6. Order picking time to reach selected pick location

#No	Item Name	Current Pick Location	Cycle time to pick from P _i (min)					Average Cycle Time(min)
			1	2	3	4	5	
1	Paracetamol- 250Mg, 500 Mg TAB	E-15-A-E	15	15.4	15.2	15.3	15.1	15.2 min
2	Glucose- 10%&50%(hypertonic)	M-14-A-E	7.5	8.5	8	9	7	8 min
3	Amoxicillin- 250Mg, 500Mg Cap	D-21-A-E	17	16.2	17.2	16.8	16.8	16.8 min
4	Tetracyclin- 1% Eye Ointment	S-17-A-E	6.2	6.3	6	5.9	6.1	6.1 min
5	Tinidazole- 250Mg, 500MG TA	X-7-A-E	3.2	3.3	3.3	3.1	3.1	3.2 min
6	Albendazole- 250Mg, 500Mg TAB	H-14-A-E	11.3	11	11.3	11.5	11.4	11.3 min
7	Doxycycline-250Mg,500Mg/5 ml	U-13-A-E	5.5	5.8	5.6	5.5	5.6	5.6 min
8	Mebendazole-100 Mg; 500 Mg TAB	K-18-A-E	8.4	8.2	8.6	8.8	9	8.6 min
9	Cloxacillin- 500Mg injection	J-16-A-E	6.3	6	6.1	6	6.1	6.1 min
10	Ceftriaxone-250,500Mg/1Gg-PF	L-2-A-E	7	7.5	8	7.4	7.6	7.5 min
11	Azithromycin*-250,500 Mg TAB	R-12-A-E	5	4	6	4	5	5 min
12	Ciprofloxacin-250,500Mg TAB	T-11-A-E	7.5	7.4	7.7	7.4	7.5	7.5 min
13	Hydrocortisone-100Mg	G-8-A-E	12.4	12.5	12.3	12.7	12.1	12.4 min
14	Ibuprofen-200mg/5ML.	Q-22-A-E	4.3	4.3	4.2	4.4	4.3	4.3 min
15	Benzylpenicillin-600MgTAB	F-22-A-E	13.5	13.4	13.3	13.2	13.6	13.4 min
16	Metronidazole-250,500 Mg	W-8-A-E	6	4	5	6	4	5 min
17	Cefalexin-125 Mg/5ml;250 mg/5 ml	V-9-A-E	4.1	4.1	4.3	4.6	4.4	4.3 min

Source: Own survey

As described on the table above, the total order picking time in order to pick those selected items in a single order tour is 140.3 minute and the average pick time is 8.25 minute. This is due the ABC-classification loss its purpose, and the random storing arrangement in the warehouse.

4.7. Order pick frequency analysis

Table 4-7. Order pick frequency

#No.	Item Name	Order Frequency (January-March 2022)
1	Paracetamol- 250Mg, 500 Mg TAB	1043
2	Glucose- 10%&50%(hypertonic)	1024
3	Amoxicillin- 250Mg, 500Mg Cap	946
4	Tetracyclin- 1% Eye Ointment	936
5	Tinidazole- 250Mg, 500MG TAB	928
6	Albendazole- 250Mg, 500Mg TAB	926
7	Doxycycline-250Mg,500Mg/5 ml	919
8	Mebendazole-100 Mg; 500 Mg TAB	886
9	Cloxacillin- 500Mg injection	847
10	Ceftriaxone-250,500Mg/1Gg-PF	775
11	Azithromycin*-250,500 Mg TAB	654
12	Ciprofloxacin-250,500Mg TAB	619
13	Hydrocortisone-100Mg	591
14	Ibuprofen-200mg/5ML.	576
15	Benzylpenicillin-600MgTAB	462
16	Metronidazole-250,500 Mg in 100-ml	432
17	Cefalexin-125 Mg/5ml;250 mg/5 ml	401
	Total	12,965

Source: Own survey & Company's data, 2022

4.8. Pickers current performance

To allow comparison between the warehouse outbound team (order pickers), evaluation of the picking process is organized by recording the time warehouse order picker spending on the different stages of order fulfillment process. Below table provide data that was recorded when pickers received those pick lists which included combination products selected by warehouse management of the agency in collaboration with the researcher. Each time measurement considered 17 different A-Class items order plans, which were found at different pick location. As, the case company “KPI (Key Performance Indicator)” shows the average picking time per line item was 1.14 minutes, accordingly those 17 items should be handover to customers within 19.38 minutes.

Table 4-8. Picker's current performance

Step	#	Activity	Senior picker			Junior picker		
			#1	#2	#3	#1	#2	#3
1.		Picker receives pick list	3min	2min	2min	3min	3 min	3min
2.	2.1	Picking process	12min	11min	12min	16min	15min	15min
		Pick up trolley → travel → search → retrieve (pick up goods) → return to the dispatch area						
	2.2	Double checking	8min	9min	7min	10min	9min	11min
	2.2.1	If correct, proceed to 3						
	2.2.2	If incorrect, inform to WM and return to 2.1 then 2.2 (On average)	6min	6min	6 min	6min	6 min	6 min
3.		Customers receive products	29min	28min	27min	35min	33min	35min
Average time used			28 minutes			34 minutes		

Source: Own survey

As the results of the measurement series indicates the average time taken by senior pickers with accumulative of 28 minutes, followed by average time taken by junior pickers with accumulative 34 minutes respectively. It shows, there is huge gap between KPI and the actual evaluated time.

To look deeply inside, I tried to measure which pick time indicator takes the highest time from the total time taken by picking process. The picking procedure is divided into four phases and the time measurements concern the:

- ✓ **Travel time:** - Time required for the picker to reach the pick point.
- ✓ **Search time:** - Time required for the products to be found.
- ✓ **Retrieval time:** - Time required for the products to be retrieved.
- ✓ **Return time:** - Time required for the picker to transport the products to the order point.

Table 4-9. Order picking process measurement indicators

	Order picking process time		
	Senior picker	Junior picker	Accumulative
Travel time	9min	13min	22min
Searching time	17min	21min	38min
Retrieval time	6min	8min	14min
Return time	3min	4min	7min
Average time used	8.75min	11.5min	

As the results of the measurement series are reported on above table, the largest time share is taken by searching time with accumulative of 38 minutes (47%), followed by travel time with the accumulative of 22 minutes (27%). The third time indicator that selected to take third longest time is retrieval time with the accumulative of 14 minutes (17.3%), return time being the last activity to take the smallest time as it is only recorded accumulative of 7 minutes (8.7%). It can be understood from this data that the agency has done little in making the warehouses easy for order picking letting it to take the more time to process order picking as this warehouse operation is the largest contributor to the better warehouse performance.

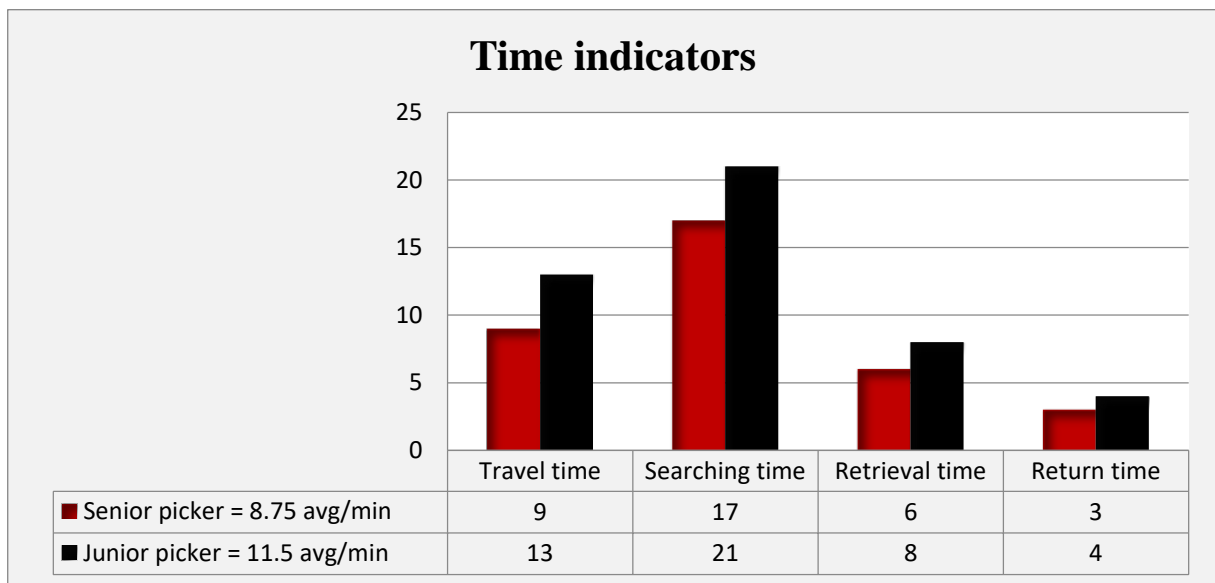


Figure 4-5. Time measurement indicators

4.9. Efficiency calculation

Efficiency is expressed as a percentage unit where 1, 0... is considered ideal and represent 100% efficiency. The ratio used to calculate efficiency is the planned order lead time (i.e. the parameter) versus the actual order lead time. This indicates the efficiency and the degree of flow in the order picking process.

Table 4-10. Actual order pick time

	Actual order picking time used	
	Senior picker	Junior picker
Total	84 minutes	103 minutes

Source: Own survey

- ✓ **SP**= Senior picker
- ✓ **JP**= Junior picker
- ✓ **KPI**= KPI =1.14 minutes per line
- ✓ **Planned order lead time** = 19.37 minutes (KPI)
- ✓ **Actual order lead time** = **SP** = 84 minutes & **JP** = 103 minutes

- **Efficiency of SP** = $\frac{19.37 \text{ minutes}}{84 \text{ minutes}} \times 100 = 23\%$

- **Efficiency of JP** = $\frac{19.37 \text{ minutes}}{103 \text{ minutes}} \times 100 = 18.8\%$

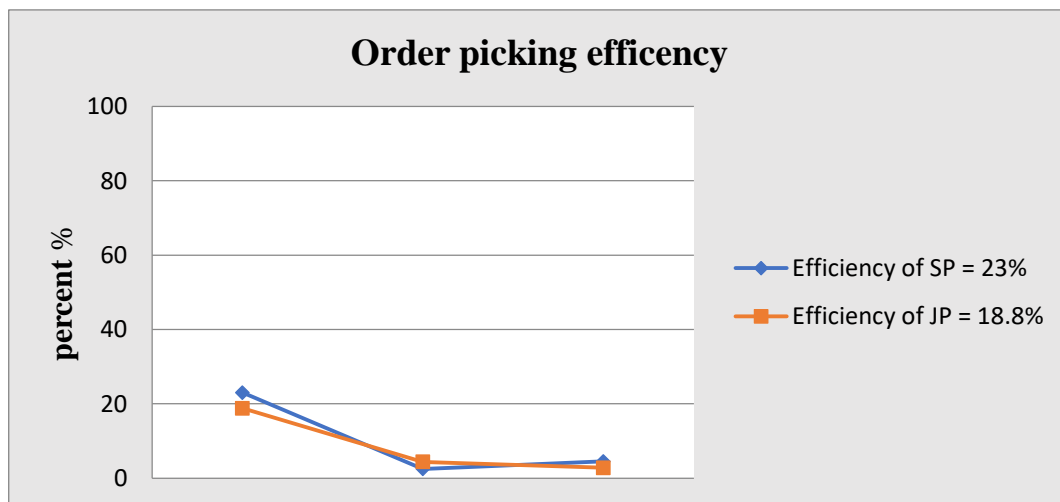


Figure 4-6. Order picking efficiency

As shown from the above figure, the order pick efficiency measurement result of “senior picker” was 23% and that of “junior picker” was 18.8% respectively. What we can understand from this is that, the performance of the warehouses is being affected much because; they are not performing in the best interest of their customers.

4.10. Pareto chart analysis

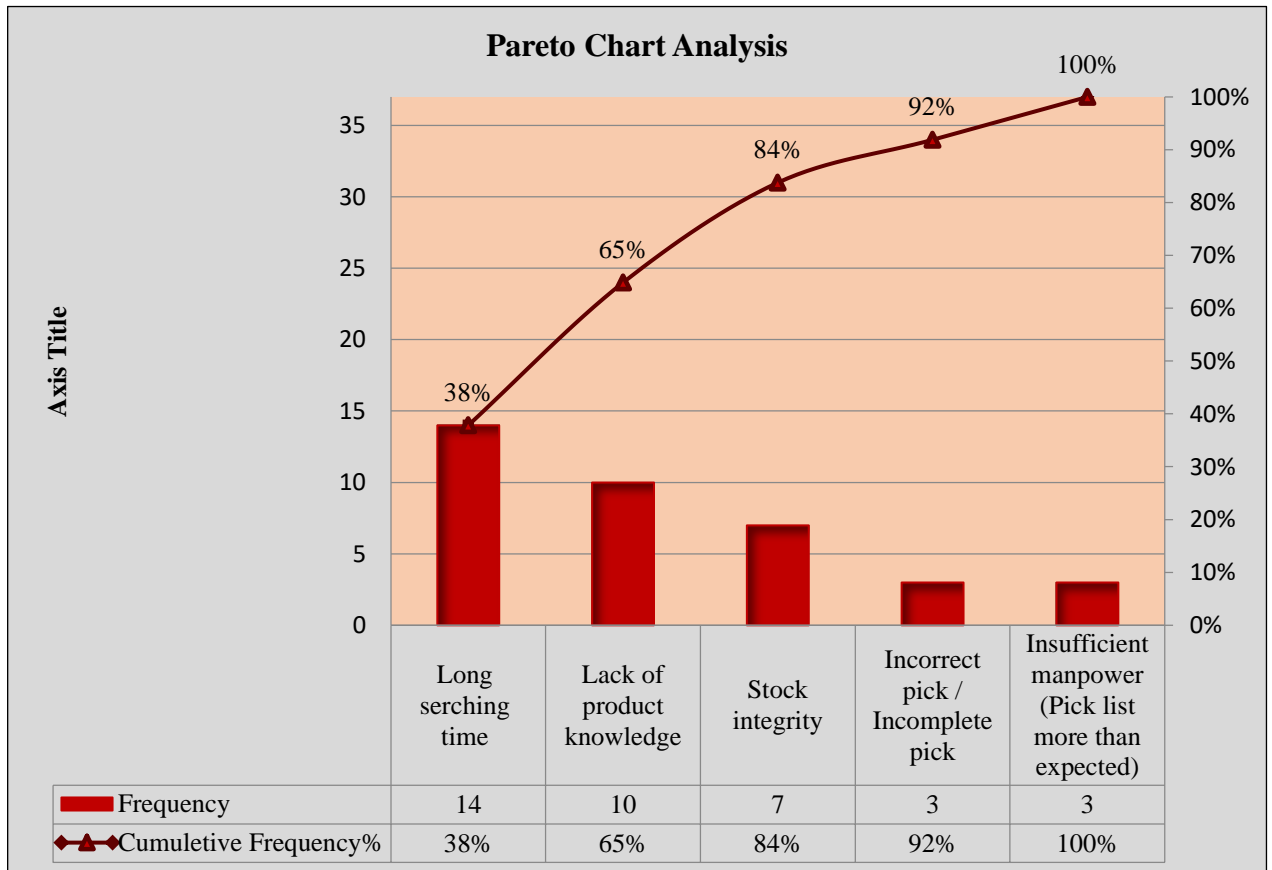
A Pareto chart is basically a bar graph in which the bars are arranged in descending order of height, starting at the left. This ‘picture’ quickly shows the fundamental problems that should be worked on first. Thus, it helps identifying and prioritizing what needs to be done first. The 80/20 rule states that 80% of problems encountered are the result of 20% of causes (Pareto Chart, n.d., para 2). There were a number of causes identified in the process. Therefore, a Pareto Chart Analysis was used to categorize the problems for review and help to point out the more prevalent problems, so the researcher could see to it that they are causes resulting in the most problems addressed. By using Pareto analysis, the major/the vital few problems that cause most of the effect on the system are identified.

Table 4-11. List of causes and frequency

#No	Causes	Frequency (within one pick tour)
1	Delay in order picking time caused by long searching time (Storage assignment policy)	14
2	Stock integrity	7
3	Incorrect pick / Incomplete pick	3
4	Pick light items before heavy items (Lack of product knowledge)	6
5	Unaware that two trolleys are required to pick huge items (Lack of product knowledge)	4
6	Insufficient manpower (Number of pick list more than expected)	3

Source: Adapted from Company data, 2022

It shows the frequency of effects or problems in rank order from the highest to lowest, then the 80/20 rule is applied.



Source: Own survey

Figure 4-7. Pareto chart analysis

As shown in above figure, long searching time, lack of product knowledge, stock integrity, Incorrect pick / Incomplete pick and Insufficient manpower (Number of pick list more than expected) were the fundamental problem areas arranged in descending order of height, starting at the left. The major/the vital problems that cause most of the effect on the system are searching time and lack of product knowledge identified. These major problems were source of 80 % problem that cause delay in order picking process and let the practice of order picking in the warehouses a little bit weak.

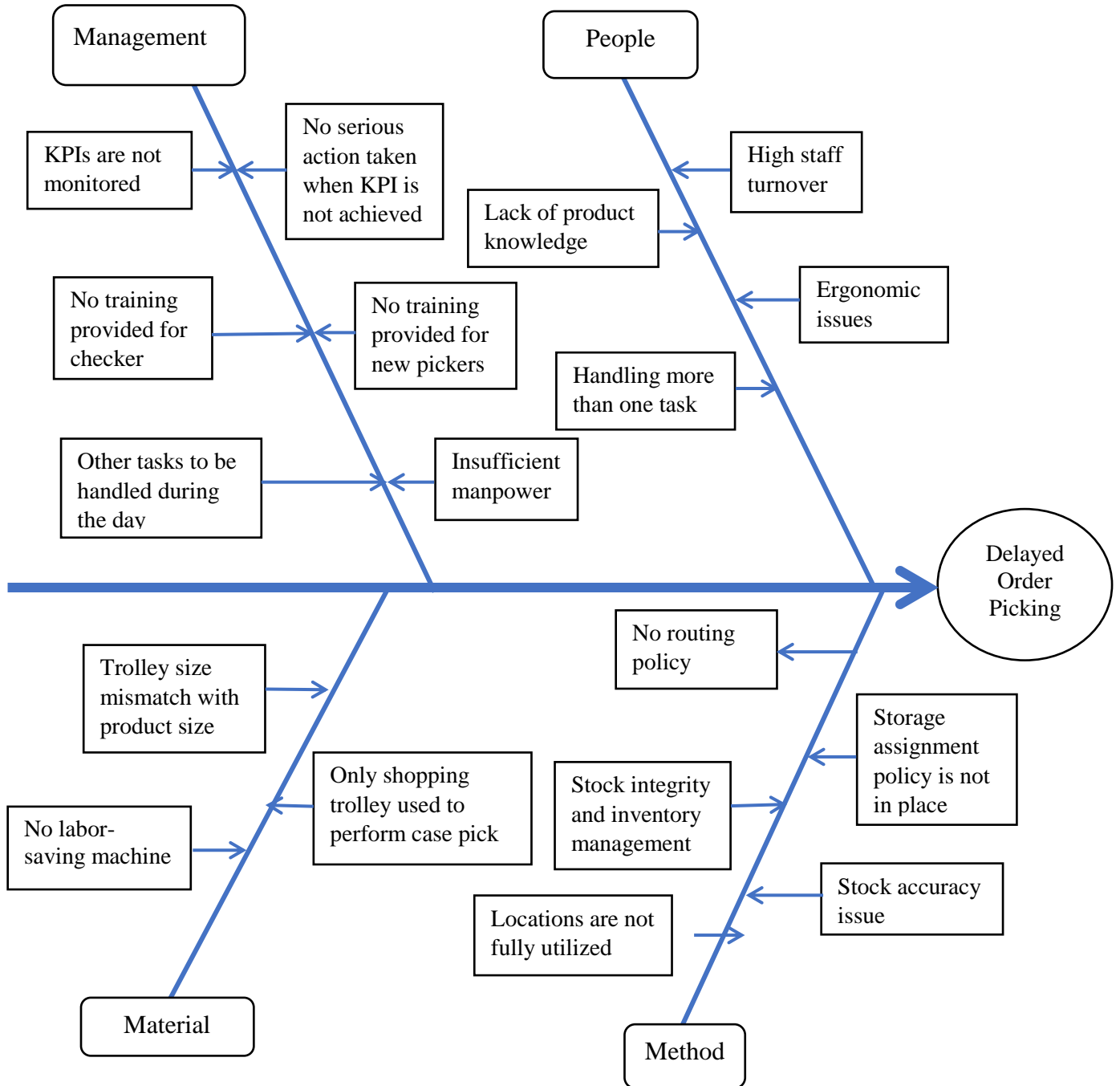
4.11. Cause-and-effect analysis

Cause and Effect analysis also called (fishbone diagram) is a graphic tool used to identify, sort, illustrate and map different causes to a problem. The structure of the diagram is similar to the bone structure of a fish, hence the name. The “head “of the fish is where the problem is stated, and from the “backbone”, a number of “bones” are connected where the possible main causes of the problem is stated. From these main bones, smaller bones are written that displays more detailed information about the causes to the problem. It is a simple qualitative tool that collects ideas of a group in a systematic way and easily facilitates understanding of a problem (Shahriari, 2011).

In the previous section of pareto chart analysis, the major/the vital problems that cause most of the effect on the system are long searching time and lack of product knowledge identified. These major problems were source of 80 % problem that cause delay in order picking process and cause-and-effect analysis was used to define the relationship between causes and their effects to identify the root causes of delay in the order picking process.

Therefore; the figure below shows the constructed diagram where the ‘fish head’ represents the effect or problem which is “delay in order picking processes” and how constraints like management, ,materials, people, labor-skill, experience, training, etc. are the factors responsible for lowing order picking process in the agency.

4.11.1. Cause and Effect diagram



Source: Own survey

Figure 4-8. Cause and effect analysis of picking process

The main propose of the improve phase of DMAIC is to improve processes and resolve the problems identified in the order picking process. This section addresses those improvements for a more efficient order picking process. The above cause and effect diagram analysis shows the major problems, which have been categorized into four areas: management, material, people and method. Pareto chart shows that delay in picking time is due to long searching times (method) and lack of product knowledge (people). These are the top two reasons that cause the delays in picking process and these contributed to waste, according to lean theory. The researcher focused on efforts to resolve these two problems with corrective actions, and proposed measures to monitor and control the process.

4.12. Assignment model formulation

Assignment model is a set of rules which determine the warehouse allocation for different items finding the optimal locator to minimize the average travel and picking time required (Goetschalckx et al. 1990). It is special case of transportation model that aims in minimization of costs, time, and distance relate to transportation. Where, d_{ij} represents time to pick the i^{th} item. Let x_{ij} denote the j^{th} rack assigned to the i^{th} item and f is the frequency.

Mathematically assignment model can be stated as:

$$\text{Minimize } Z = \sum_{i=1}^n * \sum_{j=1}^n f d_{ij} * X_{ij}$$

Subjected to

$$X_{ij} = 1 \text{ if the } j^{\text{th}} \text{ number is assigned the } i^{\text{th}} \text{ item}$$

$$0 \text{ if the } j^{\text{th}} \text{ number is not assigned the } i^{\text{th}} \text{ item}$$

Hungarian assignment method is shorter and easier compared to any other method of finding the optimal solution of an assignment problem. This method involves adding and subtracting appropriate numbers in the table to find the lowest opportunity cost for each assignment. This will be used when the rows and columns are small in number. For large number of rows and columns software packages are more appropriate.

Since we have seventeen (17) class- A items and 23- racks to be assigned. So, it is better to use POM-QM software in order to get the optimum assignment that minimizes the total order pick time. Therefore, those fast movers should be stored in more convenient area in order to improve the order picking process through minimizing the time to pick these items.

Table 4-12. Order picking travel time with pick frequency

#No.	Item Name	Average cycle time (min)	Orders frequency (January- March 2022)	Total time (min)
1	Paracetamol- 250Mg, 500 Mg TAB	15.2	1043	15853.6
2	Glucose- 10%&50%(hypertonic)	8	1024	8192
3	Amoxicillin- 250Mg, 500Mg Cap	16.8	946	15892.8
4	Tetracyclin- 1% Eye Ointment	6.1	936	5709.6
5	Tinidazole- 250Mg, 500MG TAB	3.2	928	2969.6
6	Albendazole- 250Mg, 500Mg TAB	11.3	926	10463.8
7	Doxycycline-250Mg,500Mg/5 ml	5.6	919	5146.4
8	Mebendazole-100 Mg; 500 Mg TAB	8.6	886	7619.6
9	Cloxacillin- 250Mg, 500Mg TAB	6.1	847	5166.7
10	Ceftriaxone-250,500Mg/1Gg-PF	7.5	775	5812.5
11	Azithromycin*-250,500 Mg TAB	5	654	3270
12	Ciprofloxacin-250,500Mg TAB	7.5	619	4642.5
13	Hydrocortisone-100Mg	12.4	591	7328.4
14	Ibuprofen-200mg/5ML.	4.3	576	2476.8
15	Benzylpenicillin-600MgTAB	13.4	462	6190.8
16	Metronidazole-250,500 Mg	5	432	2160
17	Cefalexin-125 Mg/5ml;250 mg/5 ml	4.3	401	1724.3
	Total time travel	140.3		110,619.4

As depicted on the table above, the total order picking travel time is 110,619.4 minute in order to pick class-A (fast mover) items which is 140.3 minutes in a single order tour. This is due the ABC-classification loss its purpose, and the random storing arrangement in the warehouse and it should be minimized. In order to minimize the total order picking travel time let's use the following scenarios.

Table 4-13. Available rack numbers with respective average cycle time to pick an order

Rack # No	Assign location	Average cycle time (min)	Rack # No	Assign Location	Average cycle time (min)
1	X (X-1 to X-22)	3.2	13	K (K-1 to K-24)	8.6
2	W (W-1 toW-22)	5	14	J (J-1to J-24)	6.1
3	V (V-1to V-22)	4.3	15	H (H-1 to H-24	11.3
4	U (V-1 toV22)	5.6	16	G (G-1 to G-24)	12.4
5	T (T-1to T-22)	7.5	17	F (F-1 to F-24)	13.4
6	S (S-1 toS-22)	6.1	18	E (E-1 to E-28)	15.2
7	R (R-1to R-22)	5	19	D (D-1 to D-28)	16.8
8	Q (Q-1 toQ-22)	4.3	20	C (C-1 to C-28)	11.3
9	P (P-1 toP-22)	5.6	21	B (B-1 to B-28)	9
10	N (N-1toN-22)	9	22	A (A-1 toA-30)	7.5
11	M (M-1to M-22)	8	23	Y (Y-1 to Y-4)	3.6
12	L (L-1 to L-24)	7.5			

Source: Own survey & Company's data, 2022

Here, we have unbalanced transportation tableau (seventeen items and twenty-three racks) and we should add dummy item with zero time to balance the transportation tableau. The POM software package inserts this dummy item to solve the problem appropriately. The next table illustrates the input information to the POM-QM software.

Table 4-14. Input data for POM-QM software

Objective																	
<input type="radio"/> Maximize <input checked="" type="radio"/> Minimize																	
Rack Assignment																	
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17
Paracetamol- 25...	3337	5215	4485	5841	7822	6362	5215	4485	5840	9387	8344	7822	8969	6362	11786	12933	13976
Glucose- 10%&5...	3278	5120	4403	5734	7680	6246	5120	4403	5734	9216	8192	7680	8806	6246	11571	12698	13722
Amoxicillin- 250M...	3027	4730	4068	5297	7095	5770	4730	4067	5297	8514	7568	7095	8135	5770	10690	11730	12678
Tetracyclin- 1% E...	2995	4680	4025	5241	7020	5709	4680	4025	5241	8424	7488	7020	8049	5709	10577	11606	12542
Tinidazole- 250M...	2969	4640	3990	5197	6960	5661	4640	3990	5196	8352	7424	6960	7980	5660	10486	11507	12435
Albendazole- 25...	2963	4630	3982	5185	6945	5648	4630	3981	5185	8334	7408	6945	7963	5648	10464	11482	12408
Doxycycline-250...	2941	4595	3951	5146	6892	5606	4595	3951	5146	8271	7352	6892	7903	5605	10385	11396	12315
Mebendazole-10...	2835	4430	3810	4961	6645	5404	4430	3809	4961	7974	7088	6645	7619	5404	10012	10986	11872
Cloxacillin- 250M...	2710	4235	3642	4743	6352	5166	4235	3642	4743	7623	6776	6352	7284	5166	9571	10503	11350
Ceftriaxone-2505...	2480	3875	3332	4340	5812	4727	3875	3332	4340	6975	6200	5812	6665	4727	8757	9610	10385
Azithromycin*-25...	2092	3270	2812	3662	4905	3989	3270	2812	3663	5886	5232	4905	5624	3989	7390	8109	8763
Ciprofloxacin-2...	1981	3095	2661	3466	4642	3776	3095	2661	3466	5571	4952	4642	5323	3775	6994	7675	8294
Hydrocortisone-1...	1891	2955	2541	3309	4432	3605	2955	2541	3309	5319	4728	4432	5082	3605	6678	7328	7919
Ibuprofen-200mg...	1843	2880	2478	3225	4320	3513	2880	2476	3225	5184	4608	4320	4953	3513	6508	7142	7718
Benzylpenicillin-6...	1478	2310	1986	2587	3465	2818	2310	1986	2587	4158	3696	3465	3973	2818	5220	5728	6190
Metronidazole-25...	1382	2160	1857	2419	3240	2635	2160	1857	2419	3888	3456	3240	3715	2635	4881	5356	5788
Cefalexin-125 M...	1283	2005	1724	2245	3007	2446	2005	1724	2245	3609	3208	3007	3448	2446	4531	4972	5373

The software solves the model using the Hungarian method and gives the following result.

Table 4-15. Rack Assignment solution

Objective																		
<input type="radio"/> Maximize <input checked="" type="radio"/> Minimize																		
Rack Assignment Solution																		
Optimal solution value = 74442	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	
Paracetamol- 250Mg 500 Mg TAB	Assign 3337	5215	4485	5841	7822	6362	5215	4485	5840	9387	8344	7822	8969	6362	11786	12933	13976	
Glucose- 10%&50%(hypertonic)	3278	5120	4403	5734	7680	6246	5120	4403	5734	9216	8192	7680	8806	6246	11571	12698	13722	
Amoxicillin- 250Mg 500Mg Cap	3027	4730	4068	5297	7095	5770	4730	Assign 4067	5297	8514	7568	7095	8135	5770	10690	11730	12678	
Tetracyclin- 1% Eye Ointment	2995	4680	Assign 4025	5241	7020	5709	4680	4025	5241	8424	7488	7020	8049	5709	10577	11606	12542	
Tinidazole- 250Mg 500MG TAB	2969	4640	3990	5197	6960	5661	Assign 4640	3990	5196	8352	7424	6960	7980	5660	10486	11507	12435	
Albendazole- 250Mg 500Mg TAB	2963	Assign 4630	3982	5185	6945	5648	4630	3981	5185	8334	7408	6945	7963	5648	10464	11482	12408	
Doxycycline-250Mg500Mg/5 ml	2941	4595	3951	5146	6892	5606	4595	3951	Assign 5146	8271	7352	6892	7903	5605	10385	11396	12315	
Mebendazole-100 Mg; 500 Mg TAB	2835	4430	3810	Assign 4961	6645	5404	4430	3809	4961	7974	7088	6645	7619	5404	10012	10986	11872	
Cloxacillin- 250Mg 500Mg TAB	2710	4235	3642	4743	6352	5166	4235	3642	4743	7623	6776	6352	7284	Assign 5166	9571	10503	11350	
Ceftriaxone-250500Mg/1Gg-PF	2480	3875	3332	4340	5812	Assign 4727	3875	3332	4340	6975	6200	5812	6665	4727	8757	9610	10385	
Azithromycin*-250500 Mg TAB	2092	3270	2812	3662	4905	3989	3270	2812	3663	5886	5232	4905	5624	3989	7390	8109	8763	
Ciprofloxacin-250500Mg TAB	1981	3095	2661	3466	4642	3776	3095	2661	3466	5571	4952	Assign 4642	5323	3775	6994	7675	8294	
Hydrocortisone-100Mg	1891	2955	2541	3309	Assign 4432	3605	2955	2541	3309	5319	4728	4432	5082	3605	6678	7328	7919	
Ibuprofen-200mg/5ML.	1843	2880	2478	3225	4320	3513	2880	2476	3225	5184	Assign 4608	4320	4953	3513	6508	7142	7718	
Benzylpenicillin-600MgTAB	1478	2310	1986	2587	3465	2818	2310	1986	2587	4158	3696	3465	Assign 3973	2818	5220	5728	6190	
Metronidazole-250500 Mg	1382	2160	1857	2419	3240	2635	2160	1857	2419	3888	3456	3240	3715	2635	4881	5356	5788	
Cefalexin-125 Mg/5ml;250 mg/5 ml	1283	2005	1724	2245	3007	2446	2005	1724	2245	Assign 3609	3208	3007	3448	2446	4531	4972	5373	
Dummy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assign 0	Assign 0	Assign 0	

As shown in the table rack are assigned for specific item and the minimized order picking travel time is found as 74,442 minutes and picking time for single order of those items is 105.9 minute which is less than the previous random assignment method. Therefore, Hungarian method gives positive result by minimizing the total order picking travel time.

Table 4-16. Comparisons result before and after implementation

Comparison result	
Before	After
110,619.4 minute	74,442 minutes
140.3 minute	105.9 minute

The researcher compared the result between before and after implementation of the storage assignment policy. The result indicates that there is a significant improvement in the order picking time, which was reduced by 34.4 minutes.

Newly proposed assignment list is summarized as follow.

Table 4-17. Item assignment list

Assignment List		
Bay Assignment		
Item name	Assigned rack No.	Time(min)
Paracetamol- 250Mg, 500 Mg TAB	R1	3337
Glucose- 10% & 50% (hypertonic)	R23	3686
Amoxicillin- 250Mg, 500Mg Cap	R8	4067
Tetracyclin- 1% Eye Ointment	R3	4025
Tinidazole- 250Mg, 500MG TAB	R7	4640
Albendazole- 250Mg, 500Mg TAB	R2	4630
Doxycycline-250Mg,500Mg/5 ml	R9	5146
Mebendazole-100 Mg; 500 Mg TAB	R4	4961
Cloxacillin- 250Mg, 500Mg TAB	R14	5166
Ceftriaxone-250,500Mg/1Gg-PF	R6	4727
Azithromycin*-250,500 Mg TAB	R22	4905
Ciprofloxacin-250,500Mg TAB	R12	4642
Hydrocortisone-100Mg	R5	4432
Ibuprofen-200mg/5ML.	R11	4608
Benzylpenicillin-600MgTAB	R13	3973
Metronidazole-250,500 Mg	R21	3888
Cefalexin-125 Mg/5ml;250 mg/5 ml	R10	3609
Minimized Total travel time		74,442

The above table shows the proper assignment of items on a rack number location that minimizes order picking travel time.

4.13. Proposed conceptual framework

The framework model proposed is based on the literature review and from the data analysis result drawn mainly from EPSA order picking performance gap, and problems found from the critical observation and interviews. This framework model based on the theoretical model of (K. Balasundaram et al 2017) adopted from “OK plastics factory” founded in Addis Ababa, Ethiopia. The case study focuses on the adoption of 5S in the industry by OK Plastics, a corporation based in Addis Ababa, Ethiopia. It explains the techniques for using the 5S to improve the efficiency of all processes in a company and the introduction of 5S shows that, the application of 5S rules has brought big changes to the company, increased the efficiency and effectiveness of processes, improved structure, productivity, quality and working conditions in OK plastics factory (Balasundaram, K., Adugna, A., Gobachew, A. M., & Kumar, M. S. 2017).

This framework model is selected because it is recent study and would help to start from the initial point as it was adopted in our country background level and can assist its users in evaluating the strengths and weaknesses on their warehouse order picking process, setting up an action plan for improvements, and modify a special part to the needs of their firm. Also the proposed model minimize the gap between case company service level and customer satisfaction with organization performance as it is easy to implement in any warehouse operations to analyze the processes that identify and eliminate unnecessary wastes, cost reduction and creating the best working conditions.; at the same time, it will further develop new designs, better storage systems and new, better methods for identifying precision parts.

4.13.1. Process of the proposed model

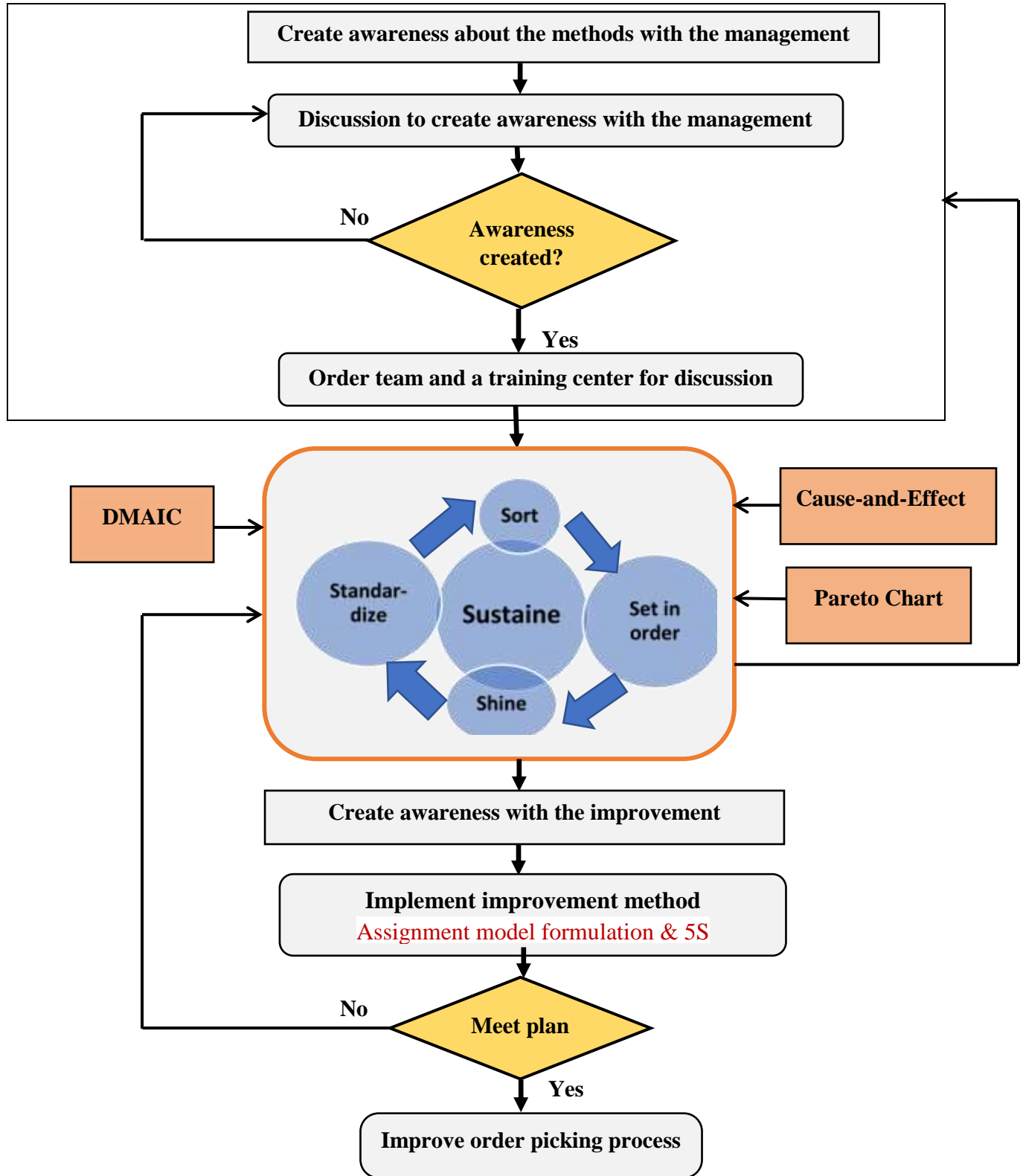


Figure 4-9. Process of the proposed model

4.13.2. Detail of the proposed improvement model

In Japan in the early 70s, one of the most well-known and popularly applied tools of Lean “5s” was origin. The main purpose of 5S practice is to provide a safe, organized and efficient workstation, resulting in a reduction of waste and improvement of performances of workers and processes (Shivanand, 2006). 5S is a step-by-step method for removing unwanted items, reducing the time spent searching for items, checking during cleanup, standardizing layouts to avoid wastage, and more the above through self-discipline. This simple cleaning method effectively reduced waste and increased productivity. Over the past decade, it has helped many industries grow without much investment (Purohit, S. R., & Shantha, V. (2015).

However, I am describing the more detailed “5s” implementation techniques (guideline) according to each S in the following manner:

1. **Seria – Sort:** “Separate the useful from the useless” That is to sort through items and keep only what is needed to perform value-added-activities and dispose of what is not. Steps to implement this are:
 - The supervisors and the workers conduct the workplace observations. Detecting and identifying which material or anything else not needed and then remove it and never store such things again. Note with symbols and dates products that need to be get rid of and keep track daily.
2. **Seiton (Set in order):** “A place for everything and everything in its place”. There must be well-defined place for everything and it needs to be checked that everything is in its place. The most frequently used equipment needs to be placed at hand to avoid unnecessary movement for the worker and visual label should be on the equipment and at the place where they must be placed.
 - All the materials have been organized and set in their fixed places. Notes have been placed on the shelves to help keeping organized storage and locations have been outlined with floor tape.
3. **Seison - Shine:** “Cleaning the workstation prevents failure conditions that could hurt the product’s quality” Having finished the sorting of unnecessary materials, and setting those in use on their dedicated places. This can be secured if the following rules and instructions are followed.
 - Worker at each station has a responsibility to clean up the workplace, tools, particularly before lunch time and after finishing the afternoon shift, each worker has to clean up his/her workstation area in about 5 to 10 minutes.

- At each processing station a small tank should be allocated for waste disposal to avoid littering the floor. Managers and team leaders are responsible for reminding workers to clean their working area frequently.
- 4. **Seiketsu (standardize):** defining “a standard regulation for order and cleanliness in the workplace (Wilson, 2009)”. In other words, develop systems and procedures, with visual controls to maintain and monitor the previous S.
 - ✓ Propose to manager and team leader of the program to clean and tidy the working area: Each worker has the right and responsibility to keep his working area clean and tidy. Propose to the head department to offer a reward or recognition for workers who perform better on the first three S. This helps to create better awareness among all workers.
- 5. **Shitsuke (Sustain):** “maintaining a stabilized workplace in an ongoing process of continuous improvement”. It must be noted that 5S is not just to organize and label material and tools and to create a shiny environment. It is a support system to lean management in order to enable smooth flow of materials and people (Shivanand, 2006). Hence, it is of great importance to sustain the culture among workers:
 - Perform all the tasks voluntarily without being reminded by team leader or manager, which seems to be unrealistic. However, the company can provide personal assessment yearly based on 5S performing, which could greatly motivate workers to sustain 5S. The team leaders should take a lead in implementing 5S and create 5S culture among all workers.

Advantages of implementation of 5S:

Successful implementation of 5S principles in many organizations brings a number of benefits, as outlined below.

1. The concept of 5S is very simple and understandable to everyone, as it requires only general knowledge of the discipline and high commitment. This practice can be done at all levels.
2. 5S will promote teamwork, discipline and a sense of responsibility and kindness towards the company.
3. 5S will create a clean and efficient work environment and provide a world-class distribution system.

CHAPTER FIVE

5. Conclusions and Recommendations

This chapter deals with conclusions and recommendations of the study. In the first section, brief conclusion, on the general study and the major findings were presented and finally possible recommendations as well as possible topics for future research listed.

5.1. Conclusion

This research was conducted to identify the root causes and find solutions of delays in order picking process faced by EPSA arbaminch. The evaluation of the picking process is organized by recording the time warehouse order picker spending on the different stages of order fulfillment process. As the case company “KPI” shows, total order pick time taken to pick selected class-A items which were found at different pick location was 19.38minutes. The average time taken by senior and junior pickers was 28minutes (23% efficiency) and 34minutes (18.8% efficiency) respectively. As the results of the measurement series indicates there is huge gap between KPI and the actual evaluated time. What we can understand from this is that, the agency has done little in making the warehouses easy for order picking practice, letting it to take the more time to process it. Which can be interpreted to increase customer complaints and loss of trust as this warehouse operation is the largest contributor to the better warehouse performance.

In order to handle this issue the researcher reviewed the related literature and determined that DMAIC was a suitable model for identifying the root causes, solving those problems, and proposing sustainable solutions. The major causes of order picking service delays discovery during the research using DMAIC model were long searching time and lack of product knowledge. This phenomenon was caused due to random storing arrangement in the warehouse and poor pickers’ educational background level. To fix this concern there were two major areas where corrective actions were devised by the researcher to improve working process and resolve problems. These included the formulation of new assignment model and development of Conceptual framework. The results after formulation of assignment model shown there is a significant improvement in order picking time. The picking time was reduced by 34.4 minutes.

5.2. Recommendation

The following measures could be taken for effective order picking process:

- It is recommended that agency needs to work on reducing the time taken by order picking process, because the time taken by order picking is longer when compared to the time of agency KPI and the administrators use the KPIs as a control mechanism to measure the actual performance of the picking process.
- Changing the storage mode of fast moving products to demand based, hence the fast moving products were placed closer to the section entrance (I/O) to reduce the travel and return times.
- The agency did not switch to zone picking, because separating the items of the different order packs needs extra time. In this method, pickers are assigned to specific zones in the warehouse and they are responsible for picking all SKU's from that zone only, which makes the picking practice easy and fast, as they are specialize on specific location.
- Introduction of a simple, Warehouse Management System (WMS): The use of a WMS can facilitate and speed up the finding of the products. This is expected to reduce significantly the search time of the total OP time.
- Conduct ongoing performance reviews, monitoring and evaluations, and continuous improvement aimed at sustainable organizational efficiency.

5.3. Suggestions for future research

The following recommendations for future research were identified during the thesis process:

- ✓ It is suggested to consider a different warehouse layout and figuring out the effects on the order picking efficiency.
- ✓ Different routing policy, with storage assignment policy as the way to improve order picking can be investigated.
- ✓ Batching policy for healthcare warehouse should be further investigated.
- ✓ Replenishment strategy for the healthcare warehouse based on the allocation; by increasing the problem size and incorporating more realistic issues.
- ✓ Cost and process of relocation of the items with dynamically changing demand pattern, in case with other storage allocation policies.

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APPENDICES

ANNEX: A

Interview questions

1. What are the challenges you face while you are doing your job in relation with order picking?
2. What part of order picking feels “hard” or “difficult”?
3. How is the material flow, exercise in the agency warehouse?
4. If item classification is taken in to use, in what it should be based on?
5. What do you do if it's empty on a picking location or if an item is placed wrong?
6. What kind of pick aid material used to pick items?
7. How do you experience the height of the different picking places, do you feel that it is difficult to pick from the pick places that are high up?
8. What do you think about the space in aisles, do you experience it crowded, when? , does it affect your work and how?
9. Out of the four time indicator measurement entities such as searching time, travel time, retrieval time , return time which is the most time taken you believe ?

ANNEX: B

