Role of Demand Forecasting and Lead Time on Waste in Supply Chain: A Case Study in Diyala Health Sector-Iraq

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Abstract—Supply Chain Management (SCM) in the healthcare sector is extremely important since it provides all requirements of patients' service. So, this paper tries to illustrate the role of demand forecasting and lead time on waste. The demand forecasting has to be precise as much as possible to avoid surplus and shortage of medicines and pharmaceutical supplies which cause several kinds of waste like inventory, over-processes, waiting and transportation. So, the main aim of this study is to figure out types of waste which can be created in pharmaceutical supply chain because of demand forecasting and lead time, and present some recommendations to improve the current situation.

This study has been conducted by case study in the pharmaceutical supply chain in Diyala province-Iraq by unstructured interviews with 15 drug store and pharmacy directors, and website. The results refer to that using demand forecasting for long-term causes surplus or shortage in some types of drugs and pharmaceutical supplies because of ambiguous future after long time, especially when the security situation is unstable which cause several types of waste in supply chain such as, inventory, over-processes, waiting and transportation which affect health service and economy at the same time, also, lack of use of modern information and communication systems affect visibility, consequently, forecasting accuracy.

Index Terms—demand forecasting, waste, case study, pharmaceutical, Diyala health sector, Iraq.

I. INTRODUCTION

The Iraqi health sector is a very huge and use centralized system i.e. all Iraqi provinces use the same pharmaceutical system and there were surplus and shortage in health sectors in all provinces including Diyala province [1]-[3]; so, the Diyala health sector was detected as a representative model to collect information about the pharmaceutical system nature in Iraqi health sector and focusing on demand forecasting procedures.

The study problem is that there is a significant amount of waste due to the surplus of inventory of some medicines because of expiry date which cost millions of dollars, whereas, there is a shortage in other types of medicines [1]-[3]. In general, the contents of the study problem can be identified through the following questions:

1) How can they estimate their medicines and pharmaceutical needs?
2) How many kinds of waste can be created because of inaccuracy of demand forecasting and lead time?

The importance of this study comes from the importance of pharmaceutical supply chain because of local limited studies in both academic and applied area in Iraq; hence, the importance of this study lies in its attempt to fill the gap in this field. In addition, medicines are essential commodities that cannot be dispensed and have to be provided permanently to the patient and reduce all kinds of waste in pharmaceutical supply chain to ensure the flow of medicines and medical appliances in suitable cost, place and time. Therefore, the importance of study can be indicated as follows:

1) Identify problems caused by needs forecasting and lead time of medicines and medical supplies.
2) Determining the types of waste resulting from needs estimating and lead time of medicines and medical supplies.
3) Provide some suggestions for solving problems related to estimating needs for medicines and medical supplies.

The study objectives try to construct a theoretical and practical framework for the study variables in a way that can achieve the following:

1) Clarify the importance of lead time and demand forecasting accuracy.
2) Determined the problems about demand forecasting of sample under study.
3) Identify which kind of waste can be created by lead time and inaccurate demand forecasting.
The pharmaceutical supply chain of Diyala health sector has been selected as a sample of this research. The sample of this research is 15 drug store and pharmacy directors as described in the table (1).

**TABLE I. DESCRIBES THE STUDY SAMPLE AND NUMBER OF DIRECTORS.**

<table>
<thead>
<tr>
<th>Research sample</th>
<th>Main store of pharmaceutical dep. in health sector bureau</th>
<th>Hospital drug store</th>
<th>Sector drug store</th>
<th>Pharmacy in hospital</th>
<th>Pharmacy of primary health care center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of directors</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
</tbody>
</table>

Source: Author’s own based on interviews.

The directors work in the pharmaceutical department in the Diyala health bureau, hospitals, health sectors and primary health care. The "Fig 1," below shows the pharmaceutical supply chain in Diyala health sector.

![Image](Figure 1. The pharmaceutical supply chain in Diyala health sector. Source: Author’s own based on interviews.)

**II. LITERATURE REVIEW**

**A. Demand Forecasting**

One of the most important keys to succeeding in supply chain management is demand forecasting. If the demand forecasting is incorrect, there will be many problems may happen throughout the entire supply chain [4]-[7]. Demand forecasting can be defined as an attempt to estimate the needs of goods, services or a combination of goods over a future period. As well as, it can be defined as an art and science to expect events in the future. Forecasting may depend on historical data (such as past sales or consume) and use a mathematical model to expect needs or sales into the future [8].

Forecasting is "one of the most important business functions because all other business decisions are based on a forecast of the future". Poor forecasting can be very costly due to incorrect decisions related to manpower plan, carrying inventory, production plan and choosing market. Because of the forecasting importance, the companies have been investing billions of dollars in state-of-the-art technologies to achieve accurate forecasting [9].

The forecasting is also different from pattern products to non-pattern products which are suitable for one unsuitable to another. Companies can predict the demand for pattern products individually as they are limited in quantity. For non-pattern products, the prediction for each item requires large financial costs, especially when the number of products is enormous, so it is best to predict them in similar groups [10].

Because of today’s changeable environment, therefore, it is hard to give a high accuracy of forecasting for individual items [11]. The demand forecasting has a significant role on bullwhip effect in supply chain. The bullwhip effect can be happening when the members of supply chain don’t expect their needs precisely which affect the manufacturers' product scheduling, capacity planning, inventory management, and part procurement multiplies leading to multiple changes in all the supply chain [4]-[7], [12]-[13]. The problems in supply chain will be less if the demand forecasting period is short [14].

The main solution to get accurate demand forecasting by making demand data at a downstream site available to the upstream site through supply chain which mean information sharing by using electronic data interchange (EDI), and build a partnership with suppliers with using vendor-managed inventory (VMI) or a continuous replenishment program (CRP) policy [15]. But for companies which do not share information, it is necessary to use mathematical methods for demand estimating [30].

There are three types of forecasting used by companies to plan their operation in future including economic forecasting, technological forecasting and demand forecasting. In this study, demand forecasting is taken into account. Demand forecasts estimate demand for a company’s products or services. Forecasts also very important to make decisions, therefore, decision makers need immediate and precise information about real demand. There are seven basic steps for forecasting steps:

1) Determine the use of the forecast.
2) Select the items to be forecasted.
3) Determine the time horizon of the forecast.
4) Select the forecasting model(s).
5) Gather the data needed to make the forecast.
6) Make the forecast.
7) Validate and implement the results [8].

Although there are several types of forecasting models which are different in complexity, there is no forecasting method can be very precise, so, forecast error, which is the difference between the actual and the forecast demand, is necessary. The companies have to make a review for demand forecasting to reduce forecast error at a minimum level. The forecast error is easy if we deal with two or three products, but the task will be complicated if we deal with a huge number of products, therefore, using computer and software is important. There are three common methods to calculate the forecast error including mean absolute deviation (MAD), mean squared error (MSE) and tracking signal [16].
B. Lead Time

Lead time is the time spent between the original customer order and final delivery of the product [17]. The bullwhip effect in supply chain will be less when the lead time of getting goods or services is short [18].

Liao & Shyu [19] mentioned in their research for building probabilistic inventory model that the lead time was one of the main variables affect inventory fluctuation. The long lead time can affect supply chain by causing bullwhip and increase on-hand inventory because of replenishment are long and uncertain, and increasing uncertainty in the forecasting of the future demand [4], [20]. Nienhaus et al. [21] also, mentioned that the longer time has the significant effect on the bullwhip effect.

C. The Concept of Waste

The organizations’ management has been paying attention towards reducing waste policy in all its activities and remove any kind of act does not add any value. This policy was first applied by Japanese Toyota Company as a lean manufacturing in 1970 and achieved excellent results. In the 1980s, the policy of reducing waste was used by American and European companies [22]. According to Womack et al., (1991), the "lean" term was used the first time by professors of MIT "Massachusetts Institute of Technology" to interpret Japan’s new production system that is far away from mass production [23].

Lean philosophy aims to eliminate all kinds of waste, continuous improvement for systems and processes, respect and preserve all workers, eliminate all activities that have non-value-added to products and use pull products by customers instead of push products i.e. producing what customers want [24]-[25]. Waste is any activity dose not add any value, and it is not only important to reduce waste in the process but to reduce costs and improve the long-term performance of the process by increasing focus on staff and management then enabling them to add value [26]. To avoid waste, companies have to focus on only value-added activities i.e. no bad parts and no inventory. So, any activity that does not add value in the eyes of the customer is a waste. Taichi Ohno, noted for his work on the Toyota Production System, identified seven categories of waste which are very popular in lean organizations. Ohno’s seven wastes are:

1) Overproduction: Producing more than the customer orders or producing early (before it is demanded) is waste.

2) Queues / waiting: Idle time, storage, and waiting are wastes (they add no value).

3) Transportation: Moving material between plants or between work centers and handling it more than once is waste.

4) Inventory: Unnecessary raw material, work-in-process (WIP), finished goods, and excess operating supplies add no value and are wastes.

5) Motion: Movement of equipment or people that adds no value is waste.

6) Over-processing: Work performed on the product that adds no value is waste.

7) Defective product: Returns, warranty claims, rework, and scrap are wastes."

Another view point takes into account energy, water, and air as other types of waste which should be avoided because the main aim of lean philosophy is minimizing inputs and maximizing outputs, wasting nothing [8].

D. Theoretical Relationship between Demand Forecasting and Lead Time, and Waste in Health Sector

The independent variables, demand forecasting and long lead time, have a significant role in all kind of supply chain, especially, in pharmaceutical supply chain because of making demand forecasting for long-term led to problems in supply chain like a surplus and shortage in medicine and pharmaceutical supplies. The surplus in the required materials leads to a high level of inventory which might be affected by storage conditions or validity of expiration date; as well as high storage costs because medicines and pharmaceutical supplies require exceptional storage conditions because they have a direct effect on human life. The surplus in medicines and pharmaceutical supplies leads to a reduction in the level of health service, also, waiting for a period to obtain needed medicines and pharmaceutical supplies. According to that, inaccurate demand forecasting and lead time may lead to several types of waste (inventory, energy, over-process, waiting, transportation and defects in the health service). This paper focuses on main four types of waste, caused by forecasting demand, (inventory, over-process, waiting and transportation) and clarifies the role of demand forecasting on them as shown in "Fig. 2,“.

![Figure 2. Role of demand forecasting on waste. Source: Author’s own.](image-url)

III. METHODOLOGY

The basis for this study were conducted through a case study. Study data was collected through unstructured interviews with 15 directors of drug store and pharmacy. The interviews were carried out over a period of eight weeks at the pharmaceutical department, hospitals, sectors and primary health care in pharmaceutical supply chain of Diyala province. The data were cross-checked
again with all the participants, who involved in interviews, to ensure reliability, validity and dependability. Unstructured interviews are one of the main collect data methods which help a researcher to understand the system nature in study field deeply and collect a huge amount of data about study field [27]. The questions of the interview are shown in the table (2).

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What is the period of receiving medicines and pharmaceutical supplies i.e. monthly or annually?</td>
</tr>
<tr>
<td>2</td>
<td>How do you determine your needs of medicines and pharmaceutical supplies, i.e. is the need determined based on the equations based on the previous data or based on personal experience or there are other ways to calculate the need?</td>
</tr>
<tr>
<td>3</td>
<td>How long between your order place and getting the medical materials?</td>
</tr>
<tr>
<td>4</td>
<td>Is there a surplus in medicines and how to deal with it and what are the reasons for the existence of surplus?</td>
</tr>
<tr>
<td>5</td>
<td>What are the order procedures of medicines and pharmaceutical supplies?</td>
</tr>
<tr>
<td>6</td>
<td>How about disposal way of damaged or expired medicines? How can you deal with?</td>
</tr>
<tr>
<td>7</td>
<td>Do you use any kind of software to manage your pharmaceutical supply chain?</td>
</tr>
</tbody>
</table>

Source: Author’s own based on literature review

IV. RESULTS

As mentioned before, the interviews including 15 main drug stores and pharmacies directors in Diyala pharmaceutical health sector to understand their system in estimating their needs (demand forecasting). Here we discuss the answer of interview questions shown in the table (2). The answer for the first question by responders was there is no accurate time for receiving medicine and pharmaceutical supplies; therefore, the supply chain will be affected because of absence of commitment which causes uncertainty and instability in supply chain [28]. In general, the Diyala health sector receives drugs or pharmaceutical supplies monthly or quarterly from the state company for marketing drugs and medical appliances. The Diyala health sector is by preparing a list of surplus medicines or pharmaceutical supplies by employees in hospital or health sector which have a surplus in medical material and medicines there was an incorrect way to estimate need which can cause a surplus in medicine and pharmaceutical supplies. This is agreeing with (Liao & Shyu, [19]; Chent et al. [4]; Nienhaus et al. [21]; Agrawal et al. [20]; Bhattacharya & Bandyopadhyay [18]; Dias [14]; Wang et al. [12] that long lead time causes fluctuation in inventories and short demand forecasting period more accurate than long period.

The answer of the fourth question that because of surplus in medical material and medicines there was an expiration in medicine and pharmaceutical supplies before 2015 when there were no financial crises in Iraq but after 2015 and because of financial crises the surplus has been reduced because they cannot get what they order.

The main way to deal with the surplus medicine and pharmaceutical supplies in Diyala health sector is by preparing a list of surplus medicines or pharmaceutical supplies by employees in hospital or health sector which have a surplus in medical material and medicines and transfer it to the pharmaceutical department in Diyala health directorate to be discussed by a committee in the pharmaceutical services division and transfer it to the hospitals and sectors within the province if they have a shortage in this kind of pharmaceutical supplies or medicines. In case of no need for pharmaceutical supplies or medicine within the same province, they will be sent to the ministry of health to be sent to the other province. In some cases, there is no need for the surplus pharmaceutical and medicines because surplus in specific type may be in all provinces; therefore, the person who has estimated the need will be responsible for the surplus in pharmaceutical supplies or drugs and a board of inquiry will be formed against him in case of expiry.

The answer of fifth question is that the procedures of medicine and pharmaceutical orders start from pharmacies and send them to the drug store in the sectors or hospitals then send them to the pharmaceutical department in Diyala health bureau which in turns send them to the state company for drug marketing and medical appliances as illustrated in "Fig. 1,".

The answer of the sixth question is that the expired medicines are processed by sending them to the state company for marketing drugs and medical appliances disposal or return it to the companies from which pharmaceutical supplies or drugs have been purchased for disposal. In case of buying pharmaceutical supplies or drugs from the private sector by Diyala health bureau and when there are an expired pharmaceutical supplies or drugs, the Diyala health bureau will be responsible for disposal.

The answer to the seventh question is that all administrative procedures are done by a manual post
without using any kind of information technology systems which agree with the Russell & Taylor [29]; Rahman et al. [7] that lack information sharing among supply chain members causes bullwhip effect along supply chain such as surplus or shortage inventory, low visibility and inaccurate forecasting demand.

According to the analysis above, most kind of waste like surplus or shortage in inventory which lead to over-processes, waiting and transportation can be happened because of long-term demand forecasting, do not use information technology and annual purchasing system. In this paper, we try to clarify the kind of waste can be happened because of inaccurate demand forecasting like inventory, over-process, waiting and transportation as illustrated in the table (3).

<table>
<thead>
<tr>
<th>Waste</th>
<th>Inventory</th>
<th>Over-processes</th>
<th>Waiting</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inaccurate demand forecasting</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Surplus</td>
<td>*</td>
<td>*</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Shortage</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Source: Author’s own

According to the table (3) above the surplus of medicines and pharmaceutical supplies led to increase inventory level which is represented one of the main reasons to increase costs and risk like energy, expiration, obsolescence and damage or spoilage, consequently, there will be lots of administrative procedures and transport them to the concerned authorities to deal with them. Whereas, shortage cause also several problems like waiting to buy needed amount of medicines or pharmaceutical supplies to fill the shortfall; there are lots of administrative procedures to buy additional amount because of the traditional system, as well as, affect the health service because of losing of pharmaceutical supplies and medicines for a while.

V. CONCLUSION

1) Using demand forecasting for a long-term causes the surplus or shortage in drugs and pharmaceutical supplies because of ambiguous future after long time, especially with an uncertain environment which causes several types of waste in supply chain like (inventory, over-processes, waiting and transportation).

2) Lack of using information and communication technology systems affecting visibility, consequently, forecasting accuracy.

3) There is no scientific way to calculate forecasting error and re-evaluate result of forecasting demand helps to keep the problem without solving.

V. RECOMMENDATIONS

1) Build a partnership with suppliers of medical material and using vendor-managed inventory (VMI) or a continuous replenishment program (CRP) policy.

2) Use sophisticated information technology systems to increase supply chain visibility and determine problems and reduce waste.

3) Calculate forecasting error by using one of forecasting error methods which are Mean absolute deviation (MAD), Mean Squared Error (MSE) and Tracking signal to avoid any kind of mistake in the future.

4) Shorten lead time of supplying medical materials from two years to monthly or at least quarterly.

REFERENCES


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