REVIEW ARTICLE

Inventory control: Its principles and application

Ankita Singh[1], Sanjeev Kumar Rasania[2], Kabita Barua[3]

[1]Senior Resident, Department of Community Medicine, Lady Hardinge Medical College, New Delhi; [2]Director Professor & Head, Department of Community Medicine Lady Hardinge Medical College, New Delhi; [3]Senior Resident, Department of Community Medicine, Lady Hardinge Medical College, New Delhi

Corresponding Author

Dr Ankita Singh, Senior Resident, Department of Community Medicine, Lady Hardinge Medical College, New Delhi - 110001
E Mail ID: ankitasingh100289@gmail.com

Citation

Singh A, Rasania SK, Barua K. Inventory control: Its principles and application. Indian J Comm Health. 2022;34(1):14-19. https://doi.org/10.47203/IJCH.2022.v34i01.004

Source of Funding: Nil **Conflict of Interest:** None declared

Article Cycle

Received: 20/10/2021; **Revision:** 15/01/2022; **Accepted:** 20/02/2022; **Published:** 31/03/2022

Abstract

Availability of good quality stock, in right quantity, at right place and time and at right cost is the essence of inventory control, which in turn is mandatory for smooth functioning and service delivery of any health care facility. Various techniques are available for inventory control, based on cost, criticality and other factors for e.g., ABC analysis, VED analysis, ABC-VED matrix, FSN analysis, SDE analysis etc. Each technique has its own strength and weakness in its applicability. Economic considerations are also imperative for logistic management of any health facility, as any cost savings could be spent more gainfully in some other way and thus more lives could be saved, reduced morbidities and overall positive impact. Future healthcare managers will have to utilize scientific methods of inventory management and the role of an efficient hospital logistics system cannot be ignored anymore. Inventory control is an important component of hospital management. It provides significant improvement in patient care, customer relationships and optimal use of resources. The objective of this paper is to present an up-to-date review of inventory control and critically appraise its various techniques, various costs associated with it and methods of indenting stock. This review will benefit post-graduate students and public health workers in understanding the concepts and principle of inventory control and applying the same in their practice.

Keywords

Logistics; Delivery of Health Care; Inventory Control

Introduction

Several striking advancements in technology and increasing incorporation of business and administrative practices into prevention and public health service delivery has an enormous impact on public health practice (1). People expect the smooth functioning of health care facility with favourable outcomes and if the health care facility does not fulfil these expectations, then the management is blamed for this lacuna. To meet these expectations, the tasks should be performed in a most efficient and effective manner. Every organisation's management process constitutes three factors: input, process and outcome. Materials and equipment form an important and vital component of inputs used in the health facilities (2) Material management is a scientific technique which is concerned with planning, organizing and controlling the flow of material from their initial purchase through internal operations to distribution to service point. The main aim of material management is to get right quantity and quality of supplies at right time, at right place, for right cost (3). Inventory control is the method of maintenance of stock at a level at which purchasing and stocking costs are the lowest possible without interference with supply (4). Stock is goods or items kept in premises of an organization and is available for sale or distribution (3). Inventory can be defined as presently idle but useable resource. It is complete list of items such as drugs, syringes etc. in stock (5). Logistics means identification, procurement, storage, transportation, distribution, maintenance and evaluation of drugs, materials and equipment (3). Human body's blood circulation system is analogous to logistics system, which transports and provides oxygen and other essential nutrients to different body tissues on a continuous and

regular basis to enable the organism to develop and live. Any fluctuation in blood supply can cause several morbidities and sometimes even collapse of the human body. Similarly, an efficient and well managed system of inventory control and logistics will ensure supply of right material at right place whenever required. Varied type, cost and complexities of the materials required in hospital e.g., consumable materials (drugs, surgical suture, medical gases), disposable items (syringes, needles, reagents, kits etc.), semi durables (surgical instruments, linen) and durables (machinery and equipment, lab instruments), is one of the challenges for effective inventory control. Moreover, maintaining huge stock will lead to increase in carrying cost and also lock up the money, which could have been spent more gainfully in some other way (6,7). A study conducted by Pillans et al. in a 1500-bedded state-funded hospital has claimed that better inventory control technique brought about 20% savings in hospital expenditure (8). In dealing with the aforementioned challenges, the primary objective of an inventory management system in a healthcare environment is to reduce inventory costs without sacrificing service level (9).

Principle of inventory control: Fast-moving items i.e., items which have larger annual consumption should be ordered frequently and since they are being ordered frequently so their safety buffer stock is maintained at low level. Buffer stock is extra stock kept as an insurance against variations in supply and consumption. It is used only at the time of emergency for unseen demands for e.g., ORS during outbreak of diarrhea. Examples of fast-moving items are PCM, amoxycillin, metformin, syringes, needles, gloves, IFA tablets, syringes, cannulas, needles, catheters, I.V. sets, cotton swabs, bandages, gauge, dressings, tape, sutures. Slow moving items i.e., whose annual consumption is not high, sufficient stocks are maintained and orders are placed less frequently. And thus, a large safety stock is maintained e.g., endoscopic devices, surgical instruments. A system has to be worked out considering the cost of items and essentiality. Lead time is the average time duration of time in days between the decision to replenish an item and its actual addition to stock. It is of two types. Internal lead time that is the time required for organizational formalities to be completed and external lead time which is the time taken in placement of order and receipt of goods. Lead time varies from item to item and from time to time. Reorder level is the stock level at which fresh order has to be placed (10, 11, 12).

ROL = [(Average daily consumption) x LT] + BS]

It will be equal to consumption expected during lead time in addition to buffer stock.

In the (Figure 1), on Y axis we have the stock level and on X axis we have time duration in days. As we can see from figure, minimum stock level is lead time stock plus buffer stock. Day zero is the day of receiving the order and at this point it is at maximum level. With passage of time the items are getting consumed and a point arrives at which we are left with minimum stock level and at this time we have to reorder. So, the fresh order is placed and, in the meantime, lead time stock is used up. Now our fresh order is arrived. The stock which was kept as a buffer stock will now be included in our working stock; and this principle is called FIFO, which means that items which were received earlier should be issued out first. And again, same cycle is repeated. For better understanding let's see an example of logistic management for vaccines. (13) Micro plans of all subcenters at PHC are compiled and vaccine and other supplies e.g., syringes, needles, cotton swabs etc. requirements are estimated. Overall estimates also include buffers stock and wastage as per acceptable wastage rates.

(Table 1) Minimum and maximum inventory control system is implemented.

If a PHC monthly requirement for pentavalent is 160 doses so,

Working stock = 160 doses

Buffer stock = 0.25% of 160 = 40 doses

Lead time stock = 0.25% of 160 = 40 doses

So, maximum stock = 40 + 40+ 160 = 240 (24 vials)

Minimum stock = 80 doses (8 vials) (also Re-order level)

Next step is indenting, receipt and issue of vaccines at PHC.

Economic considerations- economic order quantity: In any tertiary care hospital, approximately 33% of the annual operating budget is spent on buying materials and supplies, medicines being of the prime category (14). There are four types of costs associated with inventory control. Purchase cost is the actual cost of material. Our aim is to reduce this cost without compromising the quality of supplies. One important method of decreasing purchase cost is bulk buying. But bulk buying will lead to huge inventory/ stock which in turn increases carrying cost. Carrying cost is the cost of storage of stock. If annual requirement of drug is purchased in bulk, additional space/ store rooms with fittings and furniture would be required. This will lead to additional expenditure. More store keepers, pharmacists, clerks, orderlies etc. will be required to deal with stored stock. Their salaries/wages would add up the cost. Drugs also go out of use and if a newer/better alternative arrives in market then the demand of old drug purchased in bulk will reduce considerably. Also, drugs are sensitive and thermolabile. When purchased in bulk and stored for longer period they might get exposed to hot, humid weather. This may lead to disintegration, change in colour, growth of fungus in glucose, saline bottles etc. A large stock of drug (following bulk purchase) will lead to pilferage. Carrying cost may be 25 to 35 % of actual inventory cost. It can be reduced by buying in small quantities. So, we can see that purchasing cost and carrying cost oppose each other. Shortage cost is the cost of not having a material e.g., if oxygen cylinder is

out of stock in hospital, then functioning of operation theater will be seriously disrupted. The patient will suffer and this will also bring public criticism. So, arrangements have to be made to get oxygen at a premium price from market. Ordering cost is the cost of placing an order. It includes cost of stationary, postage etc. The purchase cost and carrying cost are inversely related. If we decrease the one, other will rise. But there is a point/quantity at which both are optimum. This quantity is known as ECONOMIC ORDER QUANTITY (EOQ). So, EOQ is the most economical quantity of material for which order is to be placed (15,16,17). It can be calculated by formula.

EOQ = √2 D OC / CC where,

D = Annual demand of items in units

OC = Cost of each unit

OC / CC = inventory carrying cost.

(Figure 2) Let us assume a hospital has an annual demand (D) for 25,000 nasogastric catheters and the cost of of each catheter (Co) is Rs 10/- and it costs to the hospital Rs 2/- per catheter each year in carrying cost (Cc) which includes allowance for spoilage, pilferage, insurance etc. So, to minimize the inventory cost, hospital must order 500 units. Since annual demand is 25,000 units, so there will be 50 inventory orders per year. Advantage of EOQ is each item of store can be procured in most economical quantity and item is purchased only when it is required to be purchased. Disadvantage is that this system functions correctly only if each item exhibits reasonably stable usage and lead time. If annual demand, annual carrying cost changes then EOQ will also be changed and needs to be re-calculated.

TECHNIQUES OF INVENTORY CONTROL:

ABC ANALYSIS: (Always Better Control) It is based on cost of store items and its principle is that small number of items consume large chunk of resources and vice versa (10,13). That is around 10% of drugs/materials would consume 70% of resources, 20% of drugs/materials would consume 20% of resources, 70% of drugs/materials would consume 10% of resources. So, these materials which are small in number but consume large number of resources are known as Group A items. Items which are intermediate in number and consume intermediate number of resources are group B items and items which are larger in number, but consume significantly low number of resources are group C items (11,15-19).

(Figure 3) For group A items tight control is exercised and management is done at top level. Rigid estimates of requirement should be maintained and safety stocks are kept low. For group B items moderate control is exercised and safety stocks are moderate and management is done at middle level. For group C items ordinary control measures are exercised and safety stock should be high and management is done at lower level. For conducting ABC Analysis, a list of all items is made with their annual consumption cost and arranged in descending value of their cost. The most expensive item is kept at top followed by the less expensive and so on. Cumulative cost is worked out on the list, so for the second item, the cumulative cost will be its annual cost and cumulative cost of item above it. So cumulative cost of last item will be total annual expenditure of medical store. Now mark the figure which is close to 70% of total expenditure. All items up to this figure will be group A items. This will be equivalent to only 10- 15 % of total number of drugs. Next figure to mark will be close to 90% of total annual expenditure. So the items between these two figures will be group B items. This will be around 20% of items. The remaining items will be Group C which constitutes 65 to 70% of items. The advantage of ABC analysis is that it enables the material manager to exercise selective control when he/she is confronted with large number of items. But the major limitation is that it is based on monetary value if items. Sometimes some items have low capital investments and consumption but are lifesaving and vital for hospital and thus requires constant attention.

VED ANALYSIS: The material can also be classified based on other parameter- “Criticality” which implies value of material in achieving organization’s objectives (20). Based on criticality items can be classified into three categories- vital, essential and desirable. Vital items are those whose shortage cannot be tolerated even for shorter periods and without which hospital cannot function e.g., injection adrenaline and other life saving drugs. These items should be controlled by top management. Essential items are those whose shortage can be tolerated for shorter periods only. But if not available over long period, will adversely affect the patient care as well as hospital functioning. These items should be controlled by top/middle level managers. E.g., analgesics, antibiotics. Desirable drugs are those whose shortage will not adversely affect the patient care or hospital functioning even if they are not available for longer periods. So, VED analysis is based on subjective analysis by a group of physicians and such an analysis enables the administrator to give more attention to vital and essential items (21,22).

ABC VED Matrix analysis: Findings of both ABC & VED analysis are coupled together and further categorized. Drugs in category 1 are vital and expensive, requires close monitoring and strict controls. Safety stocks may be kept low to reduce the carrying cost. Category 2 consists of drugs which are essential and of average cost. They can receive a little less priority than category 1 drugs and should be managed by middle level managers.(23,24)

Category 3 consists of drugs which are desirable and inexpensive and are thus lowest in the hierarchy of priority. They can be managed by lower level of management.(Figure 4)

SDE Analysis: When scarcity of items is common then the items are classified based on availability and are as follows: scarce, difficult to procure and easily available. Examples of scarce items are surgical pads, glucose estimation strips. Difficult to procure items are vaccines,

surgical gloves etc. and easily available items are analgesics, antacids, cotton swabs etc. Based on location, time, and other factors an item could be scarce at one time and easily available at other.

FSN ANALYSIS: Here, items are categorized based on the quantity and rate of consumption as Fast-moving items e.g., PCM, analgesics, gloves, vaccines. Slow moving items are ear/eye drops, higher antibiotics, stationary. Not moving items are obsolete drugs (nimesulide), and outdated equipments (mercury BP Apparatus)

Apart from techniques of inventory control, ways of indenting stock is also imperative for management of inventory. Indent is a document used in purchasing process to authorize the requisition of materials prior to initiate a purchase order. Stock can be idented in three ways:

- Fixed order interval system
- Fixed order size system
- Two bin system

As the name suggests, in the former the interval of indenting stock is fixed whereas in the latter the size or quantity of stock indented is fixed.

FIXED ORDER INTERVAL SYSTEM: The time interval between two consecutive order placements is fixed, but the quantity of stock ordered is determined by the stock we already have and on the lead time. The stock of various items is checked with certain periodicity called Review Period.

If the lead time is less than the review period then the quantity ordered will be difference between maximum stock and stock in hand. But if lead time is more than review time then the quantity ordered will be difference between maximum stock and stock in hand plus the items which are in pipeline that is in transit from supplies.

Let's assume the monthly ORS packet requirement of a PHC is 1000 and average daily requirement is 33. Review period is 21 days and lead time is 7 days. So, lead time stock will be lead time in days multiplied by average daily consumption of 231 packet. As shown in figure 5, on day zero of first cycle i.e., 1st of Jan, stock was received and was at maximum stock level of ORS packets that is 1000. So, with passage of time, ORS packs were consumed according to demand and the time of first review is arrived that is after 21 days. It was observed that 500 packets were consumed and we are left with 500 packets. So, the quantity ordered will be 500+ 231 (lead time stock) packs that is total 731 packs. So, on Jan 28 which is Day zero of next cycle, we again have maximum stock level that is 1000 packs. Again, after21 days, second review time arrived. Now we observe that stock in hand is 700; so, amount of ORS packets ordered this time will be [(1000 – 700) + 231] = 531.

FIXED ORDER SIZE SYSTEM: In fixed order size system fixed number of units are ordered every time. The inventory is constantly monitored and when it falls to a pre-determined level called re-order point a fresh replenishment order of fixed amount of inventory is ordered. It is perpetual inventory system that is occurring repeatedly and frequently and uninterrupted. Example Evin, an online real time vaccine logistic management system in India.

TWO BIN SYSTEM: The stock of each item is kept in two bins. One bin is for planning "sufficient stock" to meet the demand before placing the next order. Other bin is for safety stock which contains lead time stock and buffer stock. So, when the stock of first in is used up, fresh order is placed before consuming the stock of second bin. A very simple example of two bin is management of cooking gas at home. Usually two cooking gas cylinders are kept at home, but uses only one at a given time. When one cylinder is exhausted, it's refill is ordered and the second cylinder is connected to stove and in the meantime fresh cylinder is delivered and thus there is neither stock out or over stock situation.

Difference between Fixed order size system and two bin system is that former involves continuous monitoring of inventory (perpetual) and higher value items are subject to this system. It allows immediate tracking of sales and inventory levels for individual items. One way of this immediate tracking of sales is by use of barcodes. Whereas two bin system is modification of fixed order size system; but in perpetual inventory records are maintained. It is used for low value items.

Conclusion

Inventory control is an important component of hospital management and it provides significant improvement in patient care, customer relationships and optimal use of resources. In the present healthcare environment of limited resource and increased demand, optimal utilization of existing resources for contributing towards maximum benefit of beneficiaries is an essential component of hospital logistics management.

Recommendation

Due to complex nature of materials required in hospital, a single inventory policy cannot be applied universally. Hospitals need to look at their own processes and requirements. The assumption of deterministic demand hinders the applicability of models of inventory control. In addition, deployment of a model that just considers the cost without accounting for service level won't be effective in long run. Utilisation of advanced technologies such as barcode and Radio Frequency Identification (RFID), electronic software should be considered, which can help store personnel in monitoring stocks real-time and addressing issues in the process, if infrastructure permits. One of the future research directions is to develop stochastic model of inventory control.

Relevance of the study

Non availability of drugs and material supplies may cost a precious life, may cause dissatisfaction among patients and in community and also bring disrepute to health facility. To significantly improve the patient care, customer relationships and optimal use of resources, it is crucial to understand the importance of principles of inventory control and logistic management in hospitals.

Authors Contribution

All authors have contributed equally in data collection, analysis, designing and writing.

References

1. Maxcy K, Rosenau M.J, Last J.M. Public health and preventive medicine. 15th ed. United States of America. McGraw Hill. 2008:3p
2. Roy C. A study on the logistics and supply management system of drugs at different levels in Darbhanga district of Bihar.NIHFW;2006.
3. Gupta J.P, Sood A.K. Contemporary Public Health: policy planning management.1st Edition Apothecaries foundation.2005.5.82-3p
4. Sathe P.V. Epidemiology and Management for Health Care for All. 3rd Editio n. Vora Medical Publications. 2009:135-8p.
5. Gopalakrishnan P., Sundaresan M. Prentice Hall; New Delhi: 1985. Materials Management: An Integrated Approach. Available from: https://content.kopykitab.com/ebooks/2016/06/7331/sample/sample_7331.pdf
6. Charupash C., "Simulation of drug classification by ABC analysis and economic order quantity model for drug inventory management in Khon Kaen hospital", PhD thesis, Mahidol University, 2001.
7. Kritchanchai, D., "A Framework for Healthcare Supply Chain Improvement in Thailand", Operation and Supply Chain Management, 2012;5(2):103-113
8. Pillans P.I., Conry I., Gie B.E. Drug cost containment at a large teaching hospital. Pharmacoeconomics. 1992;1:377–382.
9. Manuel D. Rossetti & Nebil Buyurgan & Edward Pohl, 2012. "Medical Supply Logistics," International Series in Operations Research & Management Science, in: Randolph Hall (ed.), Handbook of Healthcare System Scheduling, chapter 0:245-280, Springer. Handle: RePEc:spr:isochp:978-1-4614-1734-7_10 DOI: 10.1007/978-1-4614-1734-7_10
10. Suwandechochai, R., Muangpat, N., "The analysis and improvement of appropriate model for medical inventory management: case study hospital", Conference of Medical Data Standard Expo, Mahidol University, Thailand, 2010:98-107.
11. Derek Waller. Operations management: A supply chain approach, Cengage Learning EMEA, 2003.
12. John Coyle, Edward Bardi, John Langley, Management of business logistics: A supply chain perspective, Thomson Learning, 2002.
13. Government of India. Cold chain and logistic management. In: M K Aggarwal, Leonard Machado, editors. Immunisation Handbook for Medical Officers [Internet]. New Delhi: MoHFW; 2017 [cited on 2021 Aug 03] Available from https://nhm.gov.in/New_Updates_2018/NHM_Components/Immunization/Guildelines_for_immunization/Immunization_Handbook_for_Medical_Officers%202017.pdf
14. Kant S, Pandaw CS, Nath LM. A management technique for effective management of medical store in hospitals. Medical store management technique. J Acad Hosp Adm 1996;8-9:41-7
15. Tom Jose V, Akhilesh JK, Sijo MT. Analysis of inventory control techniques: A comparative study. Int J Sci Res Publ 2013;3:1-6. Available from: http://www.ijsrp.org/research-paper-0313/ijsrp-p15107.pdf . [Last accessed on 2018 Oct 05].
16. Cecil C. Bozarth, Robert B. Handfield. Introduction to operations and supply chain management, Prentice Hall, 2006
17. Ronald Ballou, Business logistics: supply chain management, Prentice Hall, 2003.
18. Heizer, Jay H., Operations management, Great Britain, Prentice Hall, 2001.
19. Vaz, F.S., Ferreira, A.M., Kulkarni, M.S., Motghare, D.D. "A study of drug expenditure at a tertiary care hospital: an ABC-VED analysis", Journal of Health Management. 2008;10(1): 119–127.
20. Chungsiwapornpong, W., "Survey of drug inventory control process and performance among hospital pharmacy departments in Thailand", Master's thesis, Mahidol University, 2007
21. Suksrisomboon, C., "The development of an inventory management system for the Royal Thai Airforce", Master's thesis, Chulalongkorn Univerisity, 2007
22. Kritchanchai, D., Suwandechochai, R., "Supply chain management in health sector in Thailand: a case study", International Journal of Services, Economics and Management. 2010;2(2):211-224.
23. Gupta S., Kant S. Hospital Stores Management – An Integral Approach.Jaypee Brothers Medical Publishers(P) Ltd; New Delhi: 2000. Inventory control; pp. 60–72.
24. Das J.K. Inventory control. In: Kaushik M., Agarwal A.K., Arora S.B., editors. Essentials of Logistics and Equipment Managemnt, Manual of Post Graduate Diploma in Hospital and Health Management. Indira Gandhi National Open University, School of Health Sciences; New Delhi: 2001.

Tables

TABLE 1 STORAGE OF VACCINES AS PER GOVERNMENT OF INDIA: (13)

Level	Working stock	Buffer stock	Lead time stock	Stock	
				Max (WS+BS+LTS)	Min (BS+LTS)
PHC/UHC	1 month (4 weeks)	0.25 month (1 week)	0.25 month (1 week)	1.5 month (6 weeks)	1.5 month (6 weeks)
District level	2 months (8 weeks)	0.5 month (2 weeks)	0.25 month (1 week)	2.75 months (12 weeks)	0.75 month (3 weeks)

Figures

FIGURE 1 INVENTORY CONTROL CYCLE SHOWING CHANGES IN STOCK LEVEL WITH TIME

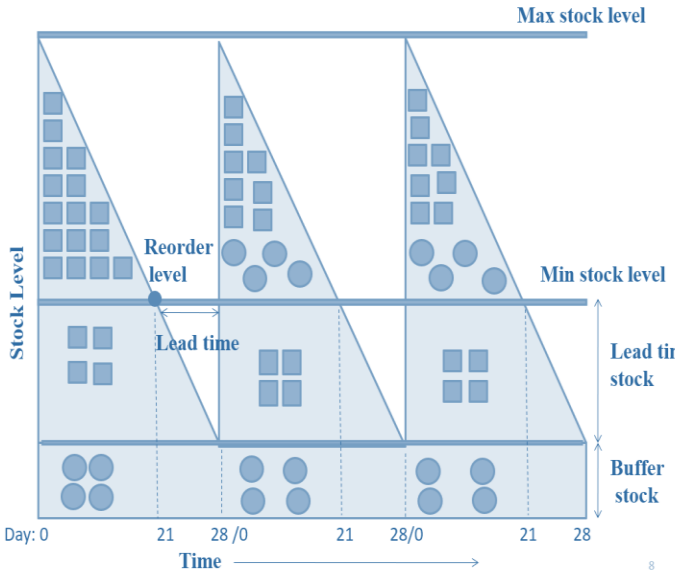

FIGURE 2 RELATIONSHIP OF VARIOUS COSTS ASSOCIATED WITH INVENTORY AND ECONOMIC ORDER QUANTITY

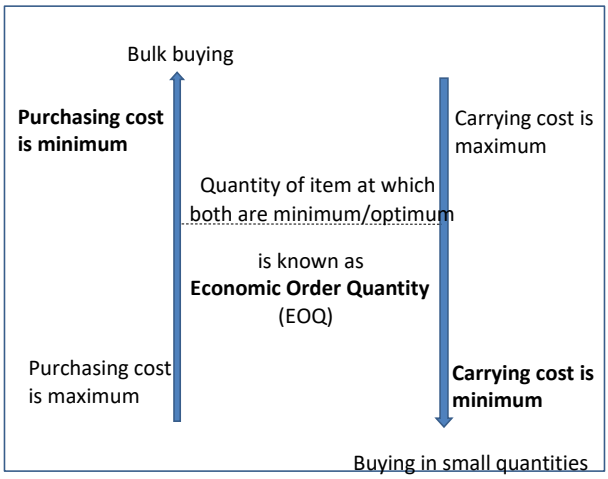

FIGURE 3 ALWAYS BETTER CONTROL ANALYSIS OF INVENTORY

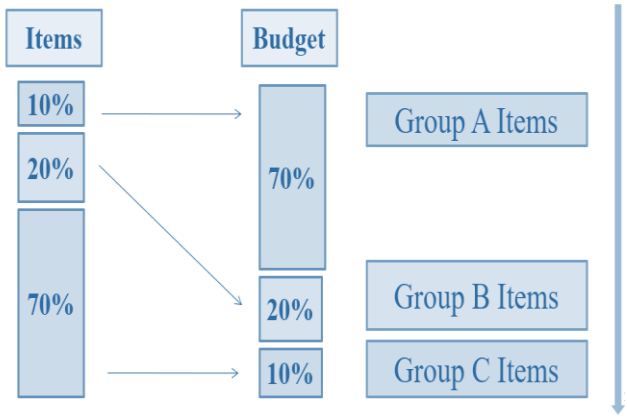

FIGURE 4 ABC- VED MATRIX ANALYSIS

CLASS	V	E	D	Categories
A	AV	AE	AD	Category I
B	BV	BE	BD	Category II
C	CV	CE	CD	Category III

FIGURE 5 FIXED ORDER INTERVAL SYSTEM OF INDENTING STOCK. (R IS STOCK AVAILABLE AT REVIEW PERIOD AND S IS MAXIMUM STOCK AVAILABLE AT STARTING OF EACH CYCLE)