Optimization of EOQ of Multi-item Inventory Control Problem through Nonlinear Programming Technique

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***Abstract:-* Inventory classification of drugs and medicines using ABC-VED analysis is the most widely employed technique in the pharmacy department of private and government hospitals both. This paper studies the optimal order policy for the economic order quantity (EOQ) inventory model under limited budget constraint. The multi-item inventory problem to obtain the optimum EOQ level has been derived as nonlinear programming problem under limited budget and number of orders in a fixed period of time constraints. Numerical illustrations have been given for different models by using secondary data.**

***Keywords* ABC-VED inventory classification, Nonlinear Programming Technique, Optimization of EOQ.**

I. INTRODUCTION

Keeping inventory in the pharmacy department of a hospital has its own various costs which may, sometimes, be more than the value of the commodity being carried out in stores. Inventory usually represents a pharmacy's largest current asset. The value of inventory to all pharmacies continues to rise owing to the increased variety and expense of pharmaceutical products. Therefore, proper management of inventory has a significant impact on both the financial and the operational aspects of any pharmacy (Huffman 1996; West 2003). Inventory management means minimizing the investment in inventory while balancing supply and demand.

Acquisition, Procurement, carrying, and stock out or shortage costs are four major costs associated with pharmacy inventory control management (Desselle, Shane P. et al, 2012). Acquisition, procurement and carrying costs can be calculated accurately and are an important financial consideration in pharmacy management. These three types of inventory costs should be monitored properly to minimize the total inventory cost. In general, shortage cost represents the failures in customer services and hence lost sales. Effective inventory management is important in meeting consumer or patient demands for both goods and services (Carroll, 1998). Not having any particular type of medicine when it is required urgently may cause a great risk towards the life of a patient.

To accomplish an effective inventory management of availability of drugs in a pharmacy, we must have a good purchasing policy, it is important for pharmacy managers to be aware of both demand and availability of vital medicines in a hospital pharmacy (West, 2003). Having the essential medicines (right product) always in the pharmacy (at right time), and at the right price is necessary to meet the patients' demand as well as to provide high quality of patient care. At the same time pharmacy management committee desire to minimize total inventory investment. However, any inventory system must answer the following two questions.

(i) How much to order for each fixed time period?
(ii) When to order to meet the requirement of vital medicines?

To minimize the total inventory costs, and to get answer of these questions, we have to model an "Optimal Economic Order Quantity Inventory Policies" under budget constraints and reorder level constraints separately.

The magnitude of inventory investment implies that there is great potential for improving the efficiency and performance of inventories in health care services. Many classical inventory models concern with single item has been developed by Resh, et al. (1976) and Hong, et al. (1990) who considered a classical lot size inventory model with linearly increasing demand. New inventory models in which item deterioration and demand are varying with time are studied by Balkhi and Benkhrouf (1996), Balkhi (1996, 1998, 2000, 2001, and 2004) and Balkhi, et al. (2001) have introduced several inventory models for different conditions of inventory control procedures. The classical multi-item inventory models under resource constraints are available in the text-books of Hadley & Whitin (1963), Ben-Daya and Raouf (1993) have developed a general single-period multi-item inventory model with budgetary or floor space constraints, where demand rate follows uniform probability distribution.

In all above articles, in general, the inventory model is developed to control the production process according to uniform demand with or without shortages. However, health care services always need the right quantity of medicines on hand to cover hospitals' or patients' emergency demand. To determine the right quantity for any medicine is very difficult because demand may fluctuate unexpectedly. In general, there are three types of stock to be considered. Cycle stock is the regular inventory that is needed to fulfill orders. Buffer of

Safety stock is additional inventory that is needed in case of sudden demand has occurred. Anticipatory or Speculative stock is inventory that is kept on hand because of expected future seasonal demand (e.g., Flu , Viral infection etc.) in a particular season. Having Anticipatory demand inventory in stock is very risky and expensive; therefore, it is not advisable to keep these medicines in stock (Desselle, et al. 2012).

To ensure adequate stock of all the required medicines in the pharmacy of any hospital, periodic review of expensive and vital drugs (life saving) weekly or twice in a month brings out about 20% savings in pharmacy store budget. The main objective of inventory management involves having to balance the conflicting economics of not wanting to hold too much stock (Adeyemi, 2010) and to provide the optimum stock at lowest cost.

In order to estimate the minimum quantity of medicines needed to meet demand, the pharmacy manager or purchasing department should know about- how much is on hand, at what point of time to reorder and how much to order? Thus, the overall goal of inventory management is to know what are needed, and to minimize the number of times any medicine is out of stock. In hospital pharmacies, formularies are utilized to enhance inventory management, where pharmacies can carry one therapeutic equivalent product within a class of medications to minimize overall inventory costs. In this paper, Optimum Economic Order Quantity of multi-item inventory control problems under available budget and total number of orders per year constraints problem has been attempted to solve for pharmacy department of a government hospital.

II. FORMULATION OF THE PROBLEM

In pharmacy inventory management problem, once all medicines are categorized according to ABC-VED analysis, we must have to obtain an Optimum EOQ model to fulfill the demands of different medicines in right time in right amount. Junita & Sari (2012) have given an Economic order interval (EOI) multiple-item inventory model for pharmacy. Panda et al. (2005) have used nonlinear goal programming technique to solve EOQ of multi-item inventory problem with priority structure of items. Such an arrangement of controlling inventory of each item is possible only if there is no constraint (limitation) on the total average inventory control systems. Chiu et al. (2004) have developed optimal order policy for EOQ model under shortage level constraints. Chen & Chang (2007) have obtained a seasonal demand inventory model with variable lead time and resource constraints applying mixed integer program with linearization technique. Balkhi, Z.T. (2014) has formulated the problem of multi-item production inventory system under different resource constraint as weighted linear programming problem. These resources includes the total warehouse space, the total investment in inventories, the total number of orders to be placed per year for all items; number of deliveries which can be accepted; size of delivery that can be handled, etc. Thus some modification to the optimal order quantity determined in classical EOQ models has to be made under certain constraints which are inevitable, such as, available fund and inventory size for pharmacy department.

2.1 The Basic EOQ model for Single Item when Shortages not permitted

To obtain the optimum economic order quantity (EOQ) model for single item when demand is assumed to be constant for one year, select an inventory policy for which the value of Q^* is optimum and ordering frequency to place reorder in that period must be chosen in such a way that the total yearly inventory cost is to be minimized.

Assumptions

- The demand is known, constant and resupplied instantaneously.
- Lead time is negligible.
- Shortages are not allowed.
- Purchase cost and reorder costs do not vary with time (for a particular year).
- Carrying cost per year is constant.
- Each item is independent and money cannot be saved by substituting by other items

The main objective to derive this model is to provide an optimum answer to real-life problems, specially problems related to pharmacy department.

Notations

C = Purchase cost of an item,

C_o = Ordering cost per order

r = Cost of carrying one rupee's worth of inventory

$C_h = C \cdot r$ = Cost of carrying one unit of an item in the inventory for a given length of time.

D_i = annual demand of i^{th} item

n = total number of items being controlled simultaneously

f_i = storage space required per unit of item i (i = 1, 2,……, n)

λ = non-negative Lagrange multiplier

Q_i = order quantity for item i in inventory (i = 1, 2,……, n)

M = upper limit of average inventory for all items in the stock

C_i = cost per unit of item i (i = 1, 2,……, n)

C_{hi} = Carrying cost of item

C_{oi} = Set-up/ordering cost of i^{th} item

F = investment limit for all items in the inventory (in Rupees)

TC = Total inventory cost (in Rupees)

TVC = Total Variable inventory Cost (in Rupees).

To determine optimal order size (Q), we need to calculate a total variable inventory cost for each order cycle. That is given by-

Total variable annual cost = Annual carrying cost + Annual ordering cost

TVC= (Average inventory level) x (Carrying cost/unit/year) + (Number of orders placed/year) x (ordering cost/order)

$$TVC = \left\{\frac{I_{max} + I_{min}}{2}\right\} \cdot C_h + \frac{D}{Q} C_0$$

$$= \frac{Q}{2} \cdot C_h + \frac{D}{Q} C_0 \qquad (2.1.1)$$

The total variable inventory cost is minimum at a value of Q which appears to be at the point where inventory carrying and ordering costs are equal. That is, $\frac{Q}{2} \cdot C_h = \frac{D}{Q} C_0$

or $$Q^2 = \frac{2D}{C_h} C_0$$

$$Q^* (EOQ) = \sqrt{\frac{2D}{C_h} C_0} = \sqrt{\frac{2 \text{ x Annual demand x ordering cost}}{\text{inventory carrying cost}}}$$

Therefore,

$$Q^* (EOQ) = \sqrt{\frac{2D \cdot C}{r.C} C_0} \qquad (2.1.2)$$

And optimal value of Q which minimize TVC can also be obtained by using differential calculus, that is, Economic Order Quantity

$$Q^* = \sqrt{\frac{2D}{C_h} C_0} \qquad (2.1.3)$$

2.2 Optimum EOQ (Q^*) model for Multi-Item Inventory Control system under Constraints

Each medicines required in the pharmacy has its own importance in different conditions. Therefore, main objective of hospital management is to decide the inventory level of all medicine or decide the optimal number of units of each medicine so as to minimize the risk associated with shortage of any medicine under budget constraints. Inventory represents a substantial investment capital for many health care organizations. Thus the decision-maker places a limit on the amount of inventory to be carried. The inventory control policy must then be adjusted to meet this objective if the total investment exceeds the limit.

2.2.1 Optimum EOQ (Q^*) model under Budget Constraint

Inventory represents a substantial investment capital for many firms. Thus the decision-maker places a limit on the amount of inventory to be carried specially in the health-care departments or pharmacy department because medicines cannot be used after expiry date. The inventory control policy must then be adjusted to meet this objective if the total investment exceeds the limit. Suppose that the inventory is controlled by a reorder level control policy (*Q*-System) under the conditions of demand and lead time certainty.

Now the problem is to minimize the total variable inventory cost under the investment constraint as -

$$\text{Min } \{TVC\} = \sum_{i=1}^{n} \left[\frac{D_i}{Q_i} C_{oi} + \frac{Q_i}{2} C_{hi}\right] \qquad (2.2.1.1)$$

Subject to the constraint

$$\sum_{i=1}^{n} C_i Q_i \le F, \text{ and } Q_i \ge 0 \text{ for all i} \qquad (2.2.1.2)$$

The above objective function (2.2.1) is Non-linear function, hence, to solve this function we have to obtain the "*Kuhn-Tucker Necessary and Sufficient Conditions for Optimal Value of TVC*". Let λ as non-negative Lagrange multiplier to define a Non-linear objective function as -

$$L(Q_i, \lambda) = TVC + \lambda \left\{\sum_{i=1}^{n} C_i Q_i - F\right\}; \quad \lambda \ge 0 \qquad (2.2.1.3)$$

Necessary conditions for L to be minimum are -

$$\frac{\partial L}{\partial Q_i} = -\frac{D_i}{{Q_i}^2} C_{oi} + \frac{1}{2} C_{hi} + \lambda C_i = 0$$

or $$Q_i^* = \sqrt{\frac{2D_i C_{oi}}{C_{hi} + 2\lambda C_i}} \text{ ; and } C_{hi} = r \times C_i \qquad (2.2.1.4)$$

$$\frac{\partial L}{\partial \lambda} = \sum_{i=1}^{n} C_i Q_i - F = 0$$

or $$\sum_{i=1}^{n} C_i Q_i = F \quad \text{(Total fund available)} \ (2.2.1.5)$$

Here λ indicates an additional cost related to the budget used by each unit of the medicines. Since Q_i^* (optimal value of Q_i) and λ values are interdependent, a trial and error method is used for different values of λ to satisfy the constraint equation on the availability of budget "F" total fund for the pharmacy department.

The Algorithm to solve the Non-linear objective function under budget constraint

Step 1: For $\lambda = 1$, compute the EOQ for each item separately by using the formula

$$Q_i{*} = \sqrt{\frac{2D_iC_{oi}}{C_{hi} + 2\lambda C_i}} \quad , i = 1, 2, \ldots\ldots , n$$

Step 2: If $Q_i{*}$, ($i = 1, 2, \ldots, n$) satisfies the condition of the total fund available, then stop the iteration procedure. Otherwise go to step 3.

Step 3: Increase the value of λ if value of left-hand side of budget constraint is more than available fund otherwise decrease the value of λ. This means that the only way of finding appropriate solution is to adjust λ iteratively until the fund required comes exactly or very close to the available fund.

2.2.2 Optimum EOQ Model under Number of Orders Constraint

In general, there is conventional approach that to find out 'reasonable' method of finding out the number of orders to maintain inventory in pharmacy not to find out the optimal value of 'number of order annually" on the basis of past data of that hospital. To find out the EOQ for actual demand of multi-item case, we should use a scientific method on the basis of past data available in that particular hospital. In multi-item inventory problem with a constraint on the number of orders to be placed per year, we have applied the method of optimization for inventory control of medicines on the basis of periodic review of data of demand available under number of order constraint which will minimize the total inventory cost. This approach can also be used where ordering cost per order and holding cost per unit per time period are not known. The following assumptions have been made to obtain the optimal number of orders per year –

(i) Ordering cost and holding cost are same for all items,
(ii) Orders are received in lots
(iii) Demand is constant
(iv) Stock outs are not allowed

Under these assumptions, the total number of orders per year ($N = D/Q$) for all items can be determined as -

Optimum number of orders per year-

$$N^* = N \times \frac{\sqrt{DC}}{\sum \sqrt{DC}}$$

Where, DC = demand in rupees; N = specified number of orders.

III. RESULT AND DISCUSSION

In Table 2.1, the Optimum EOQ $\left(Q_i^*\right)$ and corresponding optimum costs $\left(C_i^*\right)$ is computed by using Basic Inventory model given in section 2.1. Secondary data have been collected from a government hospital of Chhattisgarh state. For the available data, the cost incurred annually in a pharmacy department of that hospital is Rs. 935906.40 whereas the budget allocated to the pharmacy for that particular year is Rs. 50000.00 only. This result indicates that the extra amount used for medicines must have been managed from some other expenses which were allocated in the hospital. Because, government's policy is to provide maximum benefit directly to the general public under many "better health services program" announced for this region.

To avoid the case of over-expenses in the pharmacy, we have tried to apply some other method of minimization of cost related to purchase of medicines which comes under essential services. For this, the data of demand and purchase have been overviewed and then discussed with management committee of that hospital to know their purchase policy and procurement policy of inventory management in the pharmacy. Government hospital do not go for periodic review of consumption and purchase of medicines, instead there is conventional rule that they put their purchase order after a fixed period of time.

Order of purchasing the items has been placed in a fixed quantity twice in a year and there was situation of not being used of many items.

Thus, in view of above survey, in this paper we have suggest the non-linear programming technique under budget constraint to minimize the overall cost of medicines to meet the limited amount allocated for the pharmacy services. Then we have computed out total number of orders which should be placed in a year to procure in the pharmacy which are really in demand according to need of treatment in general. This has technique will help in minimizing the wastage of medicines due to its expiry date and hence to minimize the associated cost (amount which could not be used). Numerical results obtained by above two techniques have been given in Table 2.2 & Table 2.3.

In Table 2.2, the optimum EOQ $\left(Q_i^*\right)$ have been computed out for different values of λ, i.e. for $\lambda = 1, 2, \ldots\ldots 8$ under the limited budget Rs. 50,000.00 Then, We have computed the optimum cost for different optimum EOQ $\left(Q_i^*\right)$ for all $\lambda = 1, 2, \ldots\ldots 8$ under budget constraint A & $\lambda = 8$, we found that the value of optimum cost is Rs. 49590.57 which is very close to the budget Rs. 50,000.00 allocated to pharmacy department in that particular year. In Table 2.3, optimum cost for different values of λ i.e. $\lambda = 1, 2, \ldots\ldots, 8$ is computed. The result for $\lambda = 8$ shown in the last column of Table 2.3 shows that the optimum value of cost C_i^* is Rs 49590.57, is computed with their corresponding values of optimum quantity of different medicines i.e. value of Q_i^* as given in the last column of Table 2.3.

Table 2.4 shows the optimum number of orders would be placed in a year is computed out by using Non-linear Programming technique under "number of orders constraint to be placed in a year". The results have been shown in Table 2.4. Hence, we suggest that the Pharmacy department of a hospital should use the above scientific methods to minimize the risk associated with expiry date of medicines which have not been used in time.

All computations has been carried out by using MS-EXCEL.

IV. CONCLUSION

The use of scientific methods can be applied directly to all real life problems. Especially, in case of Pharmacy department, to compute the order quantity in different period of time as per demand and limited budget and time constrain we can use the method suggested in this paper. Hence by using scientific method, we can improve the quality adjusted life and health care service both.

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REFERENCES

[1]. **Balkhi, Zaid. T. (2014):** Muli-Item production Inventory system with Budget Constraints. Proceedings of the 1st International Conference on Manufacturing Engineering, Quality and Production System, Vol. I, pp. 232-241.

[2]. **Ben-Daya, M. and A. Raouf (1993):** On the constrained multi-item single-period inventory problem. International Journal of Production Management, Vol.13, pp. 104-112.

[3]. **Carroll, N.V. (1998):** Financial management for Pharmacists. II ed. Baltimore: Williams & Wilkins.

[4]. **Chen, Kee Kuo, Ching-Ter Chang (2007):** A Seasonal demand inventory model with lead time and resource constraints. Applied Mathematical Modelling,Vol. 31, pp. 2443-2445.

[5]. **Chiu, Singa Wang, Chia-Kuan Ting and Yuan-Shyi Peter Chiu (2004):** Optimal order policy for EOQ model under shortage level constraint. UDC 519.8: 339.

[6]. **Desselle, Shane P., Zagarrick, David P, Alston, Gregory L. (2012):** Pharmacy Management, III Ed. McGraw Hill.

[7]. **Hadley G., and Whitin, J.M. (1963):** Analysis of Inventory Systems. Prentice-Hall Company.

[8]. **Hong, J. D., Standroporty, and J.C. Hayya (1990):** On production policies for linearly increasing demand and finite production rate. Computational and Industrial Engineering, Vol. 24, pp. 143-150.

[9]. **Huffman, D.C. (1996):** Purchasing and Inventory Control-Effective Pharmacy Management. VIII Ed. Alexandria, VA; National Association of Retail Druggists, pp.355-356

[10]. **Panda, S., S. Senapati, K.Banerjee and M. Basu (2005):** Determination of EOQ of multi-item inventory problem through nonlinear goal programming. Advanced Modelling and Optimization, Vol. 7, No.2, pp.169-175.

[11]. **Resh, M, M. Friedman, and L.C. Barbosa (1976):** On general solution of a deterministic lot size problem with time proportional demand. Operations Research, Vol. 24, pp. 718-725.

[12]. **West, D.S. (2003):** Purchasing and Inventory Control. "Effective Pharmacy Management CDROM". IX Ed. Sec.17. Alexandria, VA-National Association of Retail Druggists, pp.355-356.

Table 2.1

Numerical computation for Optimum EOQ (Q^*) and Optimum Cost (C^*) by using Basic Inventory Model.

SL	ITEM	DEMAND (yearly)(units) (D_i)	COST PER UNIT (Rs) (C_i)	CARRYING COST (Rs per unit per year) (C_{hi})	SET-UP COST (Rs per set up) (C_{oi})	**Economic Order Quantity** $Q_i^* = \sqrt{2D\,C_{oi}\,C_{hi}}$	**Optimum Cost** $C_i^* = C_i \times \frac{\lambda_i}{2}$
1	Tab. Paracetamol	150000	1	100	400	10954.45	5477.226
2	Tab. Septran	100000	0.7	100	350	8366.6	2928.31
3	Tab. Metronidazole 400 mg	80000	0.47	100	300	6928.203	1628.128
4	Tab. CPM	50000	0.47	100	280	5291.503	1243.503
5	Tab. Iron - Folic	150000	2.15	100	400	10954.45	11776.03
6	Tab. Bisacodyl	5000	1	100	200	1414.214	707.1068
7	Tab. Metfarmine 500 mg	50000	1	100	280	5291.503	2645.751
8	Tab. Dexamethasone 0.5 mg	60000	0.25	100	280	5796.551	724.5688
9	Tab. Diclofanic 50 mg	100000	2.5	100	350	8366.6	10458.25
10	Tab. Aciloc 150 mg	150000	0.6	100	400	10954.45	3286.335
11	ORS	50000	15	100	280	5291.503	39686.27
12	Tab. Atenole 50 mg	25000	2	100	250	3535.534	3535.534
13	Tab. Amoxycilline 125 mg	50000	6	100	280	5291.503	15874.51
14	Syp. Antacid	25000	22	100	250	3535.534	38890.87
15	Syp. Salbutamol	25000	12	100	250	3535.534	21213.2
16	Syp. Domperidom	10000	12	100	220	2097.618	12585.71
17	Syp. Septron	50000	7	100	280	5291.503	18520.26
18	Eye drop Gentamicin Sulphate	25000	7.59	100	250	3535.534	13417.35
19	G.B. Lotion	20000	18	100	220	2966.479	26698.31
20	Inj. Paracetamol	100000	7	100	350	8366.6	29283.1
21	Inj. Cefodaxim 1gm	50000	22	100	280	5291.503	58206.53
22	Inj. Ceftrixone 500 mg	30000	30	100	250	3872.983	58094.75
23	Cream Miconazol	25000	15	100	250	3535.534	26516.5
24	Sus. Norflox - TZ	20000	18	100	220	2966.479	26698.31
25	Inj. Diclofenic	80000	20	100	300	6928.203	69282.03
26	Inj. Dicyclomine	50000	21	100	280	5291.503	55560.78
27	Inj. B-Complex	80000	5	100	300	6928.203	17320.51
28	Sus. PCM	50000	15	100	280	5291.503	39686.27
29	Syp. Chloroquine	20000	20	100	220	2966.479	29664.79
30	Inj. Aciloc	50000	3.27	100	280	5291.503	8651.607
31	Inj. Ampiciline 500 mg	80000	13	100	300	6928.203	45033.32
32	Inj. Amkacine 100 mg	20000	18	100	220	2966.479	26698.31
33	Syp. Iron - Folic	30000	35	100	250	3872.983	67777.21
34	Tab. Citrazine	25000	1	100	250	3535.534	1767.767
35	Inj. Chloroquine	25000	5.45	100	250	3535.534	9634.33
36	Inj. Deriphylline	50000	23	100	250	5000	57500
37	Iv - RL	6000	30	100	200	1549.193	23237.9
38	Iv - DS	5000	27	100	200	1414.214	19091.88
39	Iv - DNS	5000	27	100	200	1414.214	19091.88
40	Iv - NS	4000	25	100	200	1264.911	15811.39
	TOTAL					197611	935906.4

TABLE 2.2

Numerical computation for Optimum EOQ (Q^* values with budget constraint:

S.No	**Medicines name (Item)**	**Demand** (D_i)	**Cost /Unit** (C_i)	**Carrying Cost** (C_{hi})	**Set-up Cost** (C_{oi})	**Optimum EOQ** $\left(Q_i^*\right)$							
						$\left(Q_1^*\right)$ λ =1	$\left(Q_2^*\right)$ λ =2	$\left(Q_3^*\right)$ λ =3	$\left(Q_4^*\right)$ λ =4	$\left(Q_5^*\right)$ λ =5	$\left(Q_6^*\right)$ λ =6	$\left(Q_7^*\right)$ λ =7	$\left(Q_8^*\right)$ λ =8
1	Tab. Paracetamol	150000	1	100	400	1084.65	1074.17	1063.99	1054.09	1044.46	1035.09	1025.98	1017.09
2	Tab. Septran	100000	0.7	100	350	830.86	825.18	819.62	814.17	808.83	803.59	798.45	793.41

3	Tab. Metronidazole 400 mg	80000	0.47	100	300	689.59	686.39	683.25	680.15	677.09	674.07	671.09	668.15
4	Tab. CPM	50000	0.47	100	280	526.68	524.24	521.84	519.47	517.14	514.83	512.55	510.31
5	Tab. Iron – Folic	150000	2.15	100	400	1072.62	1051.17	1030.96	1011.87	993.81	976.67	960.39	944.91
6	Tab. Bisacodyl	5000	1	100	200	140.03	138.67	137.36	136.08	134.84	133.63	132.45	131.30
7	Tab. Metfarmine 500 mg	50000	1	100	280	523.94	518.87	513.95	509.17	504.52	500	495.59	491.30
8	Tab.Dexamethasone 0.5 mg	60000	0.25	100	280	578.21	576.78	575.35	573.94	572.54	571.15	569.76	568.39
9	Tab. Diclofanic 50 mg	100000	2.5	100	350	816.49	797.72	780.18	763.76	748.33	733.79	720.08	707.10
10	Tab. Aciloc 150 mg	150000	0.6	100	200	1088.93	1082.53	1076.24	1070.06	1063.99	1058.02	1052.14	1046.37
11	ORS	50000	15	100	280	464.09	418.33	383.88	356.75	334.66	316.23	300.54	286.97
12	Tab. Atenole 50 mg	25000	2	100	250	346.69	340.21	334.07	328.26	322.75	317.50	312.5	307.73
13	Tab. Amoxycilline 125 mg	50000	6	100	280	500	475.19	453.74	434.96	418.33	403.47	390.09	377.96
14	Syp. Antacid	25000	22	100	250	294.63	257.85	232.12	212.81	197.64	185.31	175.03	166.29
15	Syp. Salbutamol	25000	12	100	250	317.50	290.62	269.58	252.53	238.36	226.33	215.96	206.90
16	Syp. Domperidom	10000	12	100	220	188.37	172.42	159.94	149.83	141.42	134.28	128.13	122.75
17	Syp. Septron	50000	7	100	280	495.59	467.71	444.05	423.66	405.83	390.09	376.05	363.42
18	Eye drop Gentamicin Sulphate	25000	7.59	100	250	329.43	309.66	293.06	278.88	266.57	255.76	246.17	237.58
19	G.B. Lotion	20000	18	100	220	254.37	226.19	205.69	189.91	177.28	166.87	158.11	150.60
20	Inj. Paracetamol	100000	7	100	350	783.60	739.51	702.11	669.86	641.68	616.79	594.58	574.62
21	Inj. Cefodaxim 1gm	50000	22	100	280	440.96	385.92	347.40	318.51	295.80	277.35	261.96	248.89
22	Inj. Ceftrixone 500 mg	30000	30	100	250	306.19	261.12	231.45	210.04	193.65	180.58	169.84	160.81
23	Cream Miconazol	25000	15	100	250	310.09	279.51	256.49	238.36	223.60	211.28	200.80	191.74
24	Sus. Norflox – TZ	20000	18	100	220	254.37	226.19	205.68	189.91	177.28	166.87	158.11	150.60
25	Inj. Diclofenic	80000	20	100	300	585.54	516.39	467.09	429.66	400	375.73	355.40	338.06
26	Inj. Dicyclomine	50000	21	100	280	444.05	390.09	351.98	323.23	300.5371535	282.03	266.58	253.41
27	Inj. B-Complex	80000	5	100	300	660.58	632.45	607.64	585.54	565.68	547.72	531.36	516.39
28	Sus. PCM	50000	15	100	280	464.09	418.33	383.88	356.75	334.6640106	316.22	300.53	286.97
29	Syp. Chloroquine	20000	20	100	220	250.71	221.11	200	183.97	171.26	160.87	152.17	144.74
30	Inj. Aciloc	50000	3.27	100	280	512.65	497.61	483.81	471.10	459.35	448.43	438.25	428.74
31	Inj. Ampiciline 500 mg	80000	13	100	300	617.21	561.95	519.29	485.07	456.83	433.01	412.56	394.77
32	Inj. Amkacine 100 mg	20000	18	100	220	254.37	226.19	205.68	189.91	177.28	166.87	158.11	150.60
33	Syp. Iron – Folic	30000	35	100	250	297.04	250	219.97	198.68	182.57	169.84	159.44	150.75
34	Tab. Citrazine	25000	1	100	250	350.07	346.69	343.40	340.21	337.09	334.07	331.13	328.26
35	Inj. Chloroquine	25000	5.45	100	250	335.73	320.35	306.91	295.04	284.44	274.90	266.27	258.40
36	Inj. Deriphylline	50000	23	100	250	413.80	360.84	324.11	296.69	275.24	257.85	243.39	231.12
37	Iv – RL	6000	30	100	200	122.47	104.45	92.58	84.02	77.46	72.23	67.94	64.32

38	Iv – DS	5000	27	100	200	113.96	98.06	87.37	79.55	73.52	68.68	64.68	61.31
39	Iv – DNS	5000	27	100	200	113.96	98.06	87.37	79.55	73.52	68.68	64.68	61.31
40	Iv – NS	4000	25	100	200	103.28	89.44	80	73.03	67.61	63.24	59.62	56.57
	TOTAL					18277.4 5	17258. 22	16483. 21	15859 .13	15337. 55	14890. 08	14498. 65	14151. 05

TABLE 2.3

Numerical computation for Optimum EOQ values with budget constraint for optimum cost:

S.No	**Medicines name (Item)**	**Demand** (D_i)	**Cost /Unit** (C_i)	**Carrying Cost** (C_{hi})	**Set-up Cost** (C_{oi})	**Optimum cost** (C_i^*)							
						(C_1^*) λ =1	(C_2^*) λ =2	(C_3^*) λ =3	(C_4^*) λ =4	(C_5^*) λ =5	(C_6^*) λ =6	(C_7^*) λ =7	(C_8^*) λ =8
1	Tab. Paracetamol	150000	1	100	400	542.33	537.08	531.99	527.04	522.23	517.54	512.98	**508.54**
2	Tab. Septran	100000	0.7	100	350	290.80	288.81	286.86	284.96	283.09	281.25	279.45	**277.69**
3	Tab. Metronidazole 400 mg	80000	0.47	100	300	162.05	161.30	160.56	159.83	159.11	158.40	157.70	**157.01**
4	Tab. CPM	50000	0.47	100	280	123.77	123.19	122.63	122.07	121.52	120.98	120.45	**119.92**
5	Tab. Iron – Folic	150000	2.15	100	400	1153.10	1130.01	1108.29	1087.77	1068.34	1049.92	1032.43	**1015.78**
6	Tab. Bisacodyl	5000	1	100	200	70.01	69.33	68.68	68.04	67.41	66.81	66.22	**65.65**
7	Tab. Metfarmine 500 mg	50000	1	100	280	261.97	259.43	256.97	254.58	252.26	250.00	247.79	**245.65**
8	Tab.Dexamethasone 0.5 mg	60000	0.25	100	280	72.27	72.09	71.91	71.74	71.56	71.39	71.22	**71.04**
9	Tab. Diclofanic 50 mg	100000	2.5	100	350	1020.60	997.15	975.23	954.70	935.41	917.24	900.10	**883.88**
10	Tab. Aciloc 150 mg	150000	0.6	100	200	326.68	324.75	322.87	321.01	319.19	317.40	315.64	**313.91**
11	ORS	50000	15	100	280	3480.70	3137.47	2879.14	2675.65	2509.98	2371.70	2254.02	**2152.29**
12	Tab. Atenole 50 mg	25000	2	100	250	346.68	340.20	334.07	328.26	322.74	317.50	312.50	**307.72**
13	Tab. Amoxycilline 125 mg	50000	6	100	280	1500.00	1425.57	1361.23	1304.88	1254.99	1210.42	1170.28	**1133.89**
14	Syp. Antacid	25000	22	100	250	3240.90	2836.40	2553.31	2340.96	2174.06	2038.43	1925.38	**1829.27**
15	Syp. Salbutamol	25000	12	100	250	1905.00	1743.71	1617.49	1515.23	1430.19	1358.03	1295.80	**1241.40**
16	Syp. Domperidom	10000	12	100	220	1130.23	1034.53	959.65	898.97	848.52	805.71	768.79	**736.52**
17	Syp. Septron	50000	7	100	280	1734.58	1636.97	1554.19	1482.81	1420.43	1365.33	1316.17	**1271.97**
18	Eye drop Gentamicin Sulphate	25000	7.59	100	250	1250.19	1175.15	1112.18	1058.36	1011.65	970.64	934.24	**901.65**
19	G.B. Lotion	20000	18	100	220	2289.36	2035.72	1851.20	1709.18	1595.52	1501.89	1423.02	**1355.40**
20	Inj. Paracetamol	100000	7	100	350	2742.61	2588.28	2457.38	2344.52	2245.91	2158.77	2081.05	**2011.17**
21	Inj. Cefodaxim 1gm	50000	22	100	280	4850.54	4245.14	3821.45	3503.62	3253.84	3050.85	2881.65	**2737.80**
22	Inj. Ceftrixone 500 mg	30000	30	100	250	4592.79	3916.74	3471.83	3150.63	2904.73	2708.68	2547.62	**2412.25**
23	Cream Miconazol	25000	15	100	250	2325.65	2096.31	1923.71	1787.74	1677.05	1584.66	1506.03	**1438.05**
24	Sus. Norflox – TZ	20000	18	100	220	2289.36	2035.72	1851.20	1709.18	1595.52	1501.89	1423.02	**1355.40**
25	Inj. Diclofenic	80000	20	100	300	5855.4	5163.97	4670.99	4296.69	4000.00	3757.34	3554.09	**3380.61**
26	Inj. Dicyclomine	50000	21	100	280	4662.55	4095.99	3695.85	3393.91	3155.64	2961.39	2799.11	**2660.87**
27	Inj. B-Complex	80000	5	100	300	1651.44	1581.13	1519.11	1463.85	1414.21	1369.30	1328.42	**1290.99**
28	Sus. PCM	50000	15	100	280	3480.71	3137.47	2879.14	2675.65	2509.98	2371.70	2254.02	**2152.29**
29	Syp. Chloroquine	20000	20	100	220	2507.13	2211.08	2000.00	1839.73	1712.69	1608.79	1521.77	**1447.49**
30	Inj. Aciloc	50000	3.27	100	280	838.18	813.58	791.03	770.25	751.03	733.18	716.55	**701.00**
31	Inj. Ampiciline 500 mg	80000	13	100	300	4011.88	3652.68	3375.39	3152.96	2969.40	2814.58	2681.69	**2566.01**
32	Inj. Amkacine 100 mg	20000	18	100	220	2289.36	2035.72	1851.20	1709.18	1595.52	1501.89	1423.02	**1355.40**
33	Syp. Iron – Folic	30000	35	100	250	5198.27	4375.00	3849.49	3476.90	3195.04	2972.22	2790.34	**2638.22**
34	Tab. Citrazine	25000	1	100	250	175.03	173.34	171.70	170.10	168.54	167.03	165.56	**164.13**
35	Inj. Chloroquine	25000	5.45	100	250	914.86	872.96	836.34	803.97	775.09	749.12	725.59	**704.15**
36	Inj. Deriphylline	50000	23	100	250	4758.73	4149.70	3727.17	3412.00	3165.27	2965.33	2799.05	**2657.93**
37	Iv – RL	6000	30	100	200	1837.11	1566.69	1388.73	1260.25	1161.89	1083.47	1019.04	**964.90**
38	Iv – DS	5000	27	100	200	1538.46	1323.78	1179.50	1074.00	992.53	927.18	873.24	**827.73**
39	Iv – DNS	5000	27	100	200	1538.46	1323.78	1179.50	1074.00	992.53	927.18	873.24	**827.73**
40	Iv – NS	4000	25	100	200	1290.99	1118.03	1000.00	912.87	845.15	790.56	745.35	**707.10**
	TOTAL					80250. 87	71806.18	65769. 21	61148. 13	57449. 98	54395. 91	51813. 81	49590. 57

TABLE 2.4

Numerical computation for Optimum EOQ values with Optimum number of orders constraint:

S. No.	Medicines name (item)	Demand (D_i)	Cost/Unit	**Optimum number of orders per year** N^*
1	Tab. Paracetamol	150000	1	**9**
2	Tab. Septran	100000	0.7	**6**
3	Tab. Metronidazole 400 mg	80000	0.47	**5**
4	Tab. CPM	50000	0.47	**4**
5	Tab. Iron – Folic	150000	2.15	**2**
6	Tab. Bisacodyl	5000	1	**2**
7	Tab. Metfarmine 500 mg	50000	1	**5**
8	Tab.Dexamethasone 0.5 mg	60000	0.25	**3**
9	Tab. Diclofanic 50 mg	100000	2.5	**2**
10	Tab. Aciloc 150 mg	150000	0.6	**7**
11	ORS	50000	15	**20**
12	Tab. Atenole 50 mg	25000	2	**5**
13	Tab. Amoxycilline 125 mg	50000	6	**13**
14	Syp. Antacid	25000	22	**17**
15	Syp. Salbutamol	25000	12	**12**
16	Syp. Domperidom	10000	12	**8**
17	Syp. Septron	50000	7	**13**
18	Eye drop Gentamicin Sulphate	25000	7.59	**10**
19	G.B. Lotion	20000	18	**13**
20	Inj. Paracetamol	100000	7	**19**
21	Inj. Cefodaxim 1gm	50000	22	**24**
22	Inj. Ceftrixone 500 mg	30000	30	**21**
23	Cream Miconazol	25000	15	**14**
24	Sus. Norflox – TZ	20000	18	**13**
25	Inj. Diclofenic	80000	20	**29**
26	Inj. Dicyclomine	50000	21	**23**
27	Inj. B-Complex	80000	5	**14**
28	Sus. PCM	50000	15	**20**
29	Syp. Chloroquine	20000	20	**14**
30	Inj. Aciloc	50000	3.27	**9**
31	Inj. Ampiciline 500 mg	80000	13	**23**
32	Inj. Amkacine 100 mg	20000	18	**13**
33	Syp. Iron – Folic	30000	35	**23**
34	Tab. Citrazine	25000	1	**4**
35	Inj. Chloroquine	25000	5.45	**8**
36	Inj. Deriphylline	50000	23	**24**
37	Iv – RL	6000	30	**10**
38	Iv – DS	5000	27	**8**
39	Iv – DNS	5000	27	**8**
40	Iv – NS	4000	25	**7**