Opsi
Vol. 16, No. 2, December 2023
p-ISSN 1693-2102
e-ISSN 2686-2352

Optimizing inventory policy to mitigate stockouts during the COVID-19 pandemic: a case study of a pharmacy in Riau, Indonesia

Fransiska Hernina Puspitasari [1]*, Wilbert Chandra [1], Parama Kartika Dewa [1], V Reza Bayu Kurniawan [2]
[1]Universitas Atma Jaya Yogyakarta, Jl. Babarsari No. 43, Caturtunggal, Depok, Sleman, DIY 55281
[2]Universitas Sarjanawiyata Tamansiswa, Jl. Batikan, UH-III, Tahunan, Umbulharjo, Yogyakarta, DIY 55167

*__Corresponding Author__: fransiska.hernina@uajy.ac.id

Article history:
Received: 18 November 2023
Revised: 16 December 2023
Accepted: 22 December 2023
Published: 30 December 2023

Keywords:
Inventory policy
Lost sales
Simulation
Shortage costs

ABSTRACT
This paper studies on proposed inventory policy at a well-known pharmacy in Riau Province, Indonesia. Pharmacy X often experiences stockouts, especially during the critical period of the COVID-19 pandemic. These stockouts lead to lost sales. The Q and P inventory models are used to determine the optimal order quantity and order period using several simulation scenarios. Storage capacity and the ability of suppliers to supply drugs are constraints in this study. However, only 7 SKUs that often run out will be examined. The purpose of this paper is to minimize the shortage level of the SKUs using a parameter of shortage costs. After simulation, it was proven there was a decrease in the shortage costs in each SKU compared to the actual state. The reduction reached 23% - 74%.

DOI:
https://doi.org/10.31315/opsi.v16i2.11236

1. INTRODUCTION

The COVID-19 pandemic is a global phenomenon that has an impact on various aspects, among economic, social, political, environmental, technological, and health [1, 2, 3]. Besides, this phenomenon is also a challenge to the way individuals work (lifestyle), demand, distribution, and supply systems, which trigger crises [4, 5, 6]. The COVID-19 virus is spreading rapidly, causing many countries to require strict lockdowns and border closures [2, 3]. This policy's existence certainly has a negative impact on waiting times, consumer behavior, and productivity, which specifically results in supply chain disruptions in various industrial fields, such as FMCG, food, and health [2, 7].

Demand fluctuations are one of the disruptions that cannot be avoided and are clear evidence of the global pandemic COVID-19. The amount of unpredictable demand, supply chain disruptions, and misaligned supply quantities certainly have a major impact on product scarcity. Hence, it is crucial to manage operations and supply chains effectively [2, 8]. Effective and efficient supply chain management is done by adjusting demand and supply at the lowest cost. Fluctuations in data or distorted information can result in a bullwhip effect, which has an impact on incorrect information demand. Furthermore, inaccurate information can lead to supply chain disruptions, leading to inappropriate results, such as high forecasting errors, excessive or out-of-stock inventory, production capacity inefficiencies, poor service levels, uncertainty in production planning, scheduling and forecast difficulties, and poor relationships with suppliers/customers [9, 10, 11].

One of the effects that Tavakol et al. [9], Khiavi [10], and Pastore [11] discussed above is out-of-stock inventory, which has the potential to result in lost sales. In an effort to alter the inventory mathematical model and reduce the shortage costs that result in lost sales, Canyakmas et al. [12], Chen et al. [13], Radasanu [14], Muriana [15], and Kouki et al. [16] have also encountered this issue. Customers are hesitant to place repeat orders for these goods because of the somewhat variable demand, which is frequently influenced by the selling price. However, the supplier's purchase price—which is equally uncertain—is what accounts for the selling price's uncertainty. The inventory level is impacted by this varying demand, and occasionally there is not enough warehouse stock. This research alters the price-dependent inventory model (S, S) policy, potentially reducing lost sales [12]. Make-to-order products likewise face a similar situation [13]. This study finds the ideal order quantity by using a mathematical model to reduce the costs associated with total order, purchasing, and shortage punishment costs. These shortages have a negative effect on the company's service quality in addition to lost sales. A mathematical inventory model satisfies service-level targets so that businesses know the number of their order quantities, as opposed to concentrating on how to decrease shortages [14]. Consideration of meeting the service level is also one of its focuses of Muriana [15]. A modification of the general textbook stochastic inventory model, a probabilistic EOQ model, assuming normally distributed demand, is used for stockouts and calculates shortage costs and service levels [15]. Kouki et al. [16] also modified the model (r, Q) inventory policy to minimize total inventory costs and overcome lost sales. The aforementioned studies focus more on research papers than on real case-solving.

These studies also cover the topic of determining the ideal order quantity to avoid stockouts in real cases by taking stochastic demand into account. In a case study at one of the top healthcare organizations in the world, which supplies more than 13,000 products to 120 countries, the Silver-meal heuristic approach is utilized to solve stochastic demand, determine order quantity, and minimize total inventory costs [17]. A case study in the pharmacy industry also makes use of the traditional EOQ model, which is modified because demand follows an exponential distribution [18]. In addition, to safety stock calculations, the multinational food company, Bahlsen Polska, uses the EOQ method to tackle out-of-stock issues [19]. In case studies in five fast-moving consumer goods (FMCG) industries in Johannesburg, South Africa, inventory policy was used in conjunction with ABC analysis and a comparable Q model [20]. Because stochastic demand frequently results in stockouts, a case study in the flour manufacturing industry employs the probabilistic EOQ method [21]. Comparable to Uthayakumar & Karuppasamy [18] but distinct from it, this model solves the problem of rising consumer demand in the US automobile industry by relaxing the assumption of deterministic demand in favour of a stochastic one [22].

As a reminder that the inventory model is not only model Q where the number of order quantities is fixed, but also model P where the order period is fixed. Kholil et al. [23], Sezen [24], and Nenes et al. [25] use periodic-review systems to improve inventory policies in several real cases. A food and beverage industry in Indonesia often experiences problems with the number of orders and the number of demands for some products causing not optimal use of storage capacity [23]. Three alternative methods, namely EOQ, POQ, and min-max are used to find out the smallest total inventory cost of these three methods. A case study in a warehouse that supplies to several retailers using a periodic-review system to improve inventory policies [24]. This paper explores several different order periods using a scenario simulation system with total lost sales minimization parameters. This is almost similar to what Johansen & Hill [26] did, except he uses the (R, Q) control of periodic-review inventory system assuming normally distributed demand and numerical examples not a real case. A Greek commercial enterprise uses an inventory model (R, S) where R stands for the review period and S is the base stock to manage inventory on their varied and numerous products [25].

This research raises a real case experienced by a legendary pharmacy in Riau, Indonesia, called Pharmacy X. Pharmacy X is located in Siak Sri Indrapura sells a wide range of medicines, men’s and women’s cosmetics, and milk. Currently, buying and selling transactions are carried out directly where customers will go to pharmacies to look for the drugs needed. Because the demand for some medicines fluctuates, especially during the COVID-19 pandemic, pharmacies often cannot meet customer demand. The demand that cannot be fulfilled is the demand for cough-cold medicine. Figure 1 and Figure 2 show the comparison between demand per day with the amount of drug stock per day at Apotek X on the Combi Batuk Berdahak Jahe 100 ml. In both pictures, it can be seen that in certain periods there are stockouts, such as around January 23 – February 11,

2021. A comparison of demand with stock for other SKUs can be seen in the appendix. Pharmacy X in the process of determining the number of orders itself still uses intuition. Uncertain demand and not knowing the right method to determine the order quantity result in stockouts at Pharmacy X. The product unavailability of products in pharmacies has an impact on lost sales. This study only used 7 SKUs of cough-cold medicines that often experience out-of-stock, not all SKUs. At first, the pharmacy complained that cold cough medicines often ran out, especially those in the form of syrups, but did not specifically know which SKUs. Therefore, one of the authors made observations in January – February 2021 assisted by employees of the pharmacy. From the first 2 months, seven SKUs were selected that experienced a significant number of stockouts. However, the pharmacy only gives permission for cold cough medicine data in the form of syrup only. During those two months, seven SKUs were selected that experienced a significant number of stockouts. Table 1 shows the number of stockouts for each SKU of cold cough medicine. In addition, Pharmacy X only have limited storage capacities because their products are various. From the supplier side, Pharmacy X suppliers can provide and deliver products at certain times due to soaring demand in the COVID-19 pandemic conditions. Considering storage capacity dan supplier capabilities, this study tries to solve the problem of stockouts and lost sales using Q and P model simulations where the mentioned studies have not considered these two constraints and inventory models of Q and P simultaneously.

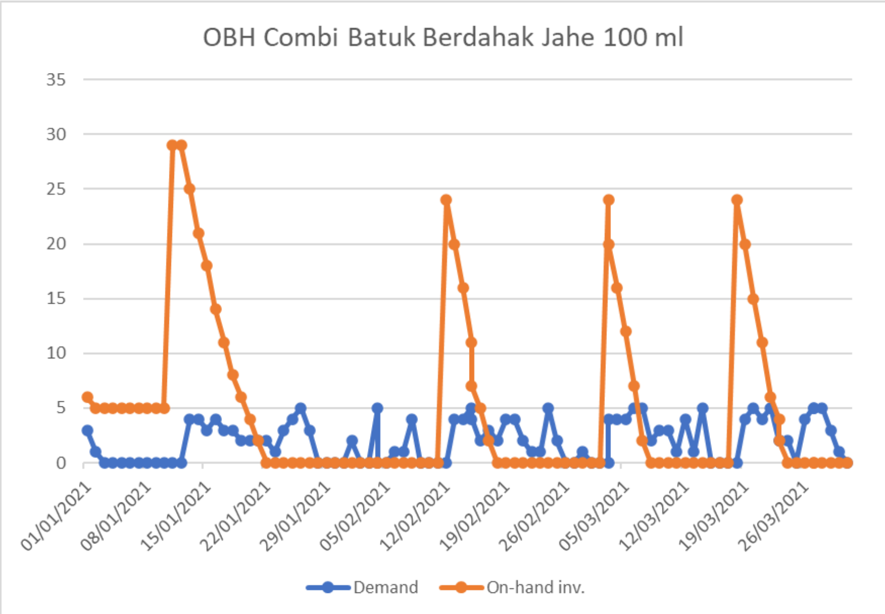

Figure 1. Demand and on-hand inventory of OBH Combi Batuk Berdahak Jahe 100 ml in January – March 2021

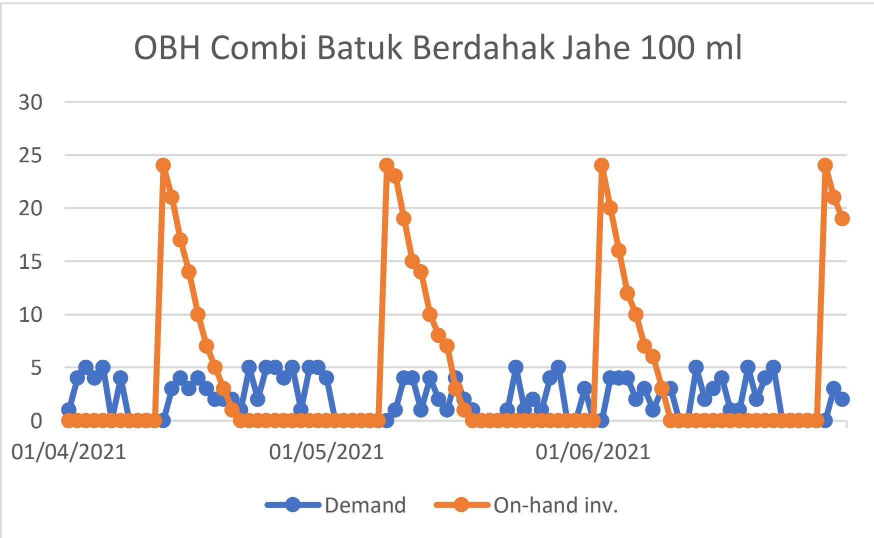

Figure 2. Demand and on-hand inventory of OBH Combi Batuk Berdahak Jahe 100 ml in April – June 2021

Table 1. A number of stockouts for cold-cough medicines in January – February 2021

No.	SKU	A number of stockouts (units)
1.	Bisolvon 60 ml	54
2.	Laserin Batuk 60 ml	51
3.	Obh Combi Batuk Berdahak Jahe 100 ml	49
4.	Bodrexin Pilek Alergi	45
5.	Remco Cough	45
6.	Bodrexin Flu Batuk Berdahak	37
7.	Decadryl 120 ml	35
8.	Actified plus cough suppressant syrup 60 ml (red)	18
9.	Ikadryl syrup 60 ml	16
10.	Vicks Formula 44 54 ml	15
11.	Actified plus cough suppressant syrup 60 ml (green)	13
12.	Obat Batuk Cap Ibu dan Anak	9

2. MATERIALS AND METHODS

The first step is to figure out the distribution type of historical demand data. Then, the second step is to do a model simulation with two scenarios is carried out. This model simulation minimizes total inventory costs (storage costs, order costs, and shortage costs) that occurred during the COVID-19 pandemic. The model must be verified whether the model created is in accordance with the desired implementation. Validation is also carried out so that it can be ensured the model is an accurate representation of the real system.

2.1. Distribution of Input Data

The type of demand data used for this inventory policy calculation is sales data. The distribution type of these sales data will be analysed. There are seven types of drugs and each drug has a coefficient of variance of more than 20%. Based on Taha (2017), data having a variance coefficient value of more than 20% is probabilistic. This probabilistic sales data is inputted into the Input Analyzer Arena to obtain the data distribution type.

In the simulation, a probability variable is raised in Microsoft Excel to bring up a demand for cold cough medicine using the RAND() function. This function uses the distribution of demand data obtained using the Input Analyzer Arena earlier. The demand for cold cough medicine is raised for a period of 180 days or 6 months.

2.2. Scenario Simulation

There are two scenarios in this study. The first scenario is to order the medicines with a fixed number of orders. The second scenario is to order the medicines with a fixed period adjusted to the supplier's period that can provide them. This inventory simulation considers the order lot size and the storage capacity of the medicines. The pharmacy said that there is no minimum purchase from the supplier, but each purchase has a lot size for each type of medicine.

This model simulation scenario will later be validated so that it can be ensured the model created is an accurate representation of the real system. After model validation, the next stage is to analyze the output of the simulation results. Replication is done because a single result does not necessarily represent the entire simulation output. The replication is carried out 10 times and then checked whether there is an overlap or not. If there is overlap, additional replication will be carried out until no overlap occurs.

2.2.1. Scenario Simulation 1

In the first simulation scenario, the medicines are ordered with a fixed number of orders. The order quantity determination is the maximum capacity of storage minus the remaining inventory. Orders are placed if the inventory level has reached the reorder point and is adjusted to the period when the supplier can supply. Each of the medicines has a different lot size that will affect the order quantity. Therefore, once the value of the order quantity is gained, it will be adjusted into several order quantity conditions based on each lot size. Some of these order quantities will later be compared.

2.2.2. Scenario Simulation 2

The difference between the first and second scenarios is in the order period and order quantity. The order period in this scenario is divided into several dates that adjust to the period the supplier can supply the product. The period of product provision is based on historical data. The order will be adjusted to the inventory level, which is the difference between existing inventory level and the maximum storage capacity.

3. RESULTS

This simulation was carried out to achieve the research objective, which is to minimize the shortage costs where the total inventory cost is also taken into account in the calculation. The total inventory cost consists of order costs, holding costs, purchase prices, and shortage costs. The holding costs are considered bank interest rates in its calculation while the order costs are obtained from communication costs between Pharmacy X and its supplier. The unit purchase price for every medicine determines the purchase costs. The shortage cost is obtained from lost sales that occur or the profit that is should be obtained if there is no shortage. The equation below is to calculate the total inventory cost.

$$B_{total} = B_{purchase} + B_{order} + B_{holding} + B_{shortage}$$

where,

B_{total} = the total inventory costs (Rp)
$B_{purchase}$ = the purchase price (Rp/box)
B_{order} = the order cost (Rp/order)
$B_{holding}$ = the holding cost (Rp/box/day)
$B_{shortage}$ = the shortage cost (Rp/box)

Each cost is verified on the Microsoft Excel sheet used.

3.1. Distribution of Input Data

The sales data analyzed is probabilistic and seven SKUs of cold cough medicines that often experience out-of-stock in Phamarcy X. These seven sales data are inputted using the Input Analyzer Arena to find the type of data distribution. These seven SKUs are OBH Combi Batuk Berdahak Jahe 100 ml, Decadryl 120 ml, Bisolvon 60 ml, Laserin Batuk 60 ml, Bodrexin Flu Batuk Berdahak, Bodrexin Pilek Alergi, dan Remco Cough. A Table 2 is the results from the Input Analyzer.

Table 2 Distribution data of seven SKUs

SKU	Distribution Type	Square Error	Corresponding P-value
OBH Combi Batuk Berdahak Jahe 100 ml	0.5+5*BETA(1.58, 1.64)	0.019682	0.073
Decadryl 120 ml	0.5+4*BETA(1.19, 1.14)	0.001615	0.555
Bisolvon 60 ml	0.5+5*BETA(1.24, 1.66)	0.004940	0.288
Laserin Batuk 60 ml	0.5+5*BETA(1.79, 1.81)	0.002279	0.655
Bodrexin Flu Batuk Berdahak	0.5+4*BETA(1.34, 1.29)	0.002637	0.447
Bodrexin Pilek Alergi	0.5+5*BETA(1.35, 1.42)	0.009340	0.164
Remco Cough	0.5+5*BETA(1.44, 1.54)	0.004563	0.433

These seven distribution types will help generate the number of demand for 180 days using the random variable functions in Microsoft Excel. For example, in OBH Combi Batuk Berdahak Jahe 100 ml: =ABS(ROUND(0.5+5*BETA.DIST(RAND(),1.58,1.64,TRUE),0)). In each SKU, verification of random number is also performed. Validation is performed between the number of demand derived from random numbers and the number of actual demands using the statistical test t-Test Two-sample Assuming Unequal Variances. The purpose is to determine the difference between the average actual demand dan the simulation data demand if there is a significant difference. The result of this validation stated that there was no significant difference between the actual demand and the simulated one of the seven SKUs.

3.2. Simulation Model

In the simulation model, the beginning inventory is obtained from the remaining inventory on the previous day. For example, the beginning inventory on day 10 is equal to the remaining inventory on day 9. The calculation of remaining inventory on day 9. The calculation of the remaining inventory is obtained from the beginning inventory on that day minus the number of demands for that day. For example, the remaining inventory on day 20 is the beginning inventory on day 20 minus the number of demands on day 20. In addition, the lead time for ordering each SKU is one day.

Storage capacity data is taken from measurements directly at the storage area of Pharmacy X. For order quantity, there is no minimum purchase, but there is a lot size for each SKU in every purchase. Table 2 below presents the storage capacity and lot size for each SKU.

Table 3. Storage capacity and lot size for each SKU

SKU	Capacity (boxes)	Lot Size (unit)
OBH Combi Batuk Berdahak Jahe 100 ml	32	6
Decadryl 120 ml	36	4
Bisolvon 60 ml	32	4
Laserin Batuk 60 ml	32	4
Bodrexin Flu Batuk Berdahak	36	4
Bodrexin Pilek Alergi	36	4
Remco Cough	32	4

3.2.1. Scenario Simulation 1

In this simulation scenario 1, the number of orders is fixed, and several variations are also carried out so that a performance comparison of each quantity is obtained. For example, for Bisolvon 60 ml, it has a maximum capacity of 32 boxes. The first Q is the maximum capacity of 32 boxes. Next, it will be simulated for 180 days. The order quantity determination is the maximum capacity of storage minus the remaining inventory. Based on that note, it is obtained the Q values are 26, 29, 32. Then, they will be adjusted with lot size of 4 boxes which results Q = 24, 28, and 32. The period when the supplier can supply products to Pharmacy X in scenario 1 uses historical data. In this case, based on the historical data, it is assumed that every 1st to 15th of each month the supplier can provide the products. In addition, the number of replications in this simulation is a minimum of 10 replications or until no overlap occurs. If the number of replications has reached 10 times, but there is still overlap, then the number of replications will be increased. The results of the scenario simulation 1 can be seen in Table 4

Table 4. The optimum order quantities, average shortage costs, and average total inventory costs of scenario simulation 1

SKU	Order Quantity (boxes)	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
OBH Combi Batuk Berdahak Jahe 100 ml	Q = 24	Rp 889,480.00	Rp 4,431,074.64
	Q = 30	Rp 680,060.00	Rp 4,102,926.92
Decadryl 120 ml	Q = 28	Rp 271,000.00	Rp 5,640,630.00
	Q = 32	Rp 153,750.00	Rp 6,207,680.46
	Q = 36	Rp 508,500.00	Rp 4,308,757.83
Bisolvon 60 ml	Q = 24	Rp 2,484,594.00	Rp 13,821,926.28
	Q = 28	Rp 2,227,050.00	Rp 14,631,583.29
	Q = 32	Rp 1,868,958.00	Rp 15,722,365,49
Laserin Batuk 60 ml	Q = 24	Rp 505,920.80	Rp 3,126,005.05
	Q = 28	Rp 431,545.40	Rp 3,349,550.29

SKU	Order Quantity (boxes)	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Bodrexin Flu Batuk Berdahak	Q = 32	Rp 340,572.10	Rp 3,294,757.42
	Q = 28	Rp 249,598.80	Rp 3,105,971.26
	Q = 32	Rp 169,340.60	Rp 3,304,650.69
	Q = 36	Rp 470,203.80	Rp 2,490,644,62
Bodrexin Flu Batuk Berdahak	Q = 28	Rp 249,598.80	Rp 3,105,971.26
	Q = 32	Rp 169,340.60	Rp 3,304,650.69
	Q = 36	Rp 470,203.80	Rp 2,490,644,62
Bodrexin Pilek Alergi	Q = 28	Rp 392,041.80	Rp 3,069,485.61
	Q = 32	Rp 308,931.90	Rp 3,340,808.36
	Q = 36	Rp 559,742.40	Rp 2,735,409.15
Remco Cough	Q = 24	Rp 1,321,979.50	Rp 2,674,686.49
	Q = 28	Rp 1,037,740.50	Rp 2,586,642.60
	Q = 32	Rp 901,520.30	Rp 2,613,896.49

Based on the table above, each SKU is simulated to various order quantities (Q) with the provisions for the number of replications described above. Each of these order quantities is simulated for 180 days using generated demand data then calculated average shortage costs and average total inventory costs. As the simulation that has been done, the optimal order quantity for OBH Combi Batuk Berdahak Jahe 100 ml is 30 boxes, Decadryl 120 ml is 32 boxes, Bisolvon 60 ml is 32 boxes, Laserin Batuk 60 ml is 32 boxes, Bodrexin Flu Batuk Berdahak is 32 boxes, Bodrexin Pilek Alergi is 32 boxes, and Remco Cough is 32 boxes. The number of orders was chosen because it resulted in the least average shortage costs.

3.2.2. Scenario Simulation 2

In this simulation scenario 2, the order quantity is not fixed, but the order period is fixed. An appointment date of order is adjusted to historical data related to several dates on which suppliers can provide products and types of simulated products. Furthermore, the order quantity is adjusted to the maximum inventory with the inventory level at the time the order was placed. For example, in SKU OBH Combi Batuk Berdahak Jahe 100 ml, the appointment date of the order suppliers can provide products is, generally, the beginning of the month to the middle of the month so that 7 variations of the order period are obtained. The order periods when a supplier can provide them vary from time to time depending on each product. Table 5 summarizes the result of scenario simulation 2.

Table 5. The optimum order period, average shortage costs, and average total inventory costs of scenario simulation 2

SKU	Order Period (date)	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
OBH Combi Batuk Berdahak Jahe 100 ml	P = 1 and 8	Rp 940,910.00	Rp 3,832,312.67
	P = 6 and 13	Rp 802,530.00	Rp 4,020,073.31
Decadryl 120 ml	P = 22 and 27	Rp 348,000.00	Rp 5,651,744.88
	P = 23 and 28	Rp 421,250.00	Rp 5,478,854.22
	P = 25 and 30	Rp 487,000.00	Rp 5,055,945.98
Bisolvon 60 ml	P = 1 and 8	Rp 2,558,478.46	Rp 11.105.845.50
	P = 2 and 9	Rp 2,416,340.77	Rp 10,783,452.09
	P = 3 and 10	Rp 3,521,140.00	Rp 11,553,699.99
	P = 4 and 11	Rp 3,325,140.00	Rp 11,556,644.92
	P = 5 and 12	Rp 3,413,340.00	Rp 11,481,948.05
	P = 6 and 13	Rp 3,304,560.00	Rp 11,466,207.67
	P = 7 and 14	Rp 2,292,860.77	Rp 11,671,197.62
Laserin Batuk 60 ml	P = 1 and 8	Rp 479,238.10	Rp 3,191,472.06
	P = 2 and 9	Rp 518,947.00	Rp 3,285,568.79
	P = 3 and 10	Rp 737,240.00	Rp 3,243,073.83

SKU	Order Period (date)	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Bodrexin Flu Batuk Berdahak	P = 4 and 11	Rp 464,321.00	Rp 3,207,850.52
	P = 5 and 12	Rp 691,859.30	Rp 3,300,212.71
	P = 6 and 13	Rp 439,109.00	Rp 3,308,491.44
	P = 7 and 14	Rp 427,553.50	Rp 3,347,828.77
	P = 21 and 26	Rp 345,194.30	Rp 3,088,775.43
	P = 22 and 27	Rp 371,036.60	Rp 3,071,601.21
	P = 23 and 28	Rp 415,577.80	Rp 3,112,322.84
	P = 24 and 29	Rp 479,238.10	Rp 2,915,056.65
	P = 25 and 30	Rp 527,140.90	Rp 2,879,447.43
Bodrexin Pilek Alergi	P = 21 and 26	Rp 453,124.80	Rp 3,146,362.47
	P = 22 and 27	Rp 491,995.80	Rp 3,090,234.06
	P = 23 and 28	Rp 621,565.80	Rp 3,112,052.85
	P = 24 and 29	Rp 550,587.60	Rp 2,941,322.99
	P = 25 and 30	Rp 660,621.90	Rp 2,897,136.46
Remco Cough	P = 1 and 8	Rp 1,296,773.40	Rp 2,641,702.24
	P = 2 and 9	Rp 1,371,855.40	Rp 2,720,851.81
	P = 3 and 10	Rp 1,319,298.00	Rp 2,617,404.04
	P = 4 and 11	Rp 1,221,155.10	Rp 2,744,784.15
	P = 5 and 12	Rp 1,260,305.00	Rp 2,667,260,49
	P = 6 and 13	Rp 1,356,839.00	Rp 2,745,266.95
	P = 7 and 14	Rp 1,362,202.00	Rp 2,843,216.99

Based on the simulation results above, an optimal order period for each SKU is obtained. The optimal order period for OBH Combi Batuk Berdahak Jahe 100 ml is on the 6th and 13th, Decadryl 120 ml is on the 22nd and 27th, Bisolvon 60 ml is on the 7th and 14th, Laserin Batuk 60 ml is on the 7th and 14th, Bodrexin Flu Batuk Berdahak is on the 21st and 26th, Bodrexin Pilek Alergi is on the 21st and 26th, and Remco Cough is on the 4th and 11th. These selected order periods have the lowest shortage costs compared to other periods.

4. DISCUSSION

The purpose of this study is to minimize the shortage costs caused by frequent stockouts for the seven drug SKUs. However, the least shortage costs do not guarantee the lowest total inventory cost either. The total inventory cost is still calculated so that Pharmacy X knows the estimated cost when it stores a certain number of units for each type of product.

After simulating these two scenarios, the next step is to further review the results of scenario 1 and scenario 2 with actual conditions in Phamarcy X. The actual condition that occurs in Phamarcy X still uses intuition in determining the number of orders. Table 6 is a comparison table between the actual conditions, simulation scenario 1, and simulation scenario 2.

Table 6 Comparison among the actual condition, scenario simulation 1, and scenario simulation 2

	OBH Combi Batuk Berdahak Jahe 100 ml	
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	1,276,500.00	3,264,943.47
Scenario 1 Q = 30	680,060.00	4,102,926.92
Scenario 2 P = 6 & 13	820,530.00	4,020,073.31
	Decadryl 120 ml	
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	787,500.00	3,385,941.25
Scenario 1 Q = 32	153,750.00	6,207,680.46
Scenario 2 P = 22 & 27	348,000.00	5,651,744.88

	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Bisolvon 60 ml		
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	2,963,520.00	10,026,650.88
Scenario 1 Q = 32	1,868,958.00	15,722,365.46
Scenario 2 P = 7 & 14	2,292,860.77	11,671,197.62
Laserin Batuk 60 ml		
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	1,291,929.00	3,241,773.09
Scenario 1 Q = 32	340,572.10	3,294,757.42
Scenario 2 P = 7 & 14	427,533.50	3,347,828.77
Bodrexin Flu Batuk Berdahak		
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	712,239.00	2,300,816.08
Scenario 1 Q = 32	169,340.60	3,304,650.49
Scenario 2 P = 21 & 26	345,194.30	3,088,775.43
Bodrexin Pilek Alergi		
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	560,853.00	2,545,053.78
Scenario 1 Q = 32	308,931.90	3,340,808.36
Scenario 2 P = 21 & 26	453,124.80	3,146,362.47
Remco Cough		
	Average Shortage Costs (Rp)	Average Total Inventory Costs (Rp)
Actual	1,512,366.00	2,656,153.15
Scenario 1 Q = 32	901,520.30	2,613,896.49
Scenario 2 P = 21 & 26	1,221,155.10	2,744,784.15

Table 6 shows the actual condition of the shortage as evidenced by large shortage costs and small total inventory costs. The total value of inventory costs is relatively small because the lack of inventory in the warehouse causes Pharmacy X to be unable to meet consumers' demand so the holding cost is small. It is also caused the pharmacy ordered in small quantities and infrequent order frequency. In the simulation, the total inventory may arise compared to the actual condition. However, the pharmacy asked if there is an increase in total inventory costs, the increase is around 30-35%.

Based on the comparison table above, the optimal order quantity for each SKU can be seen in bold. For instance, the optimal order quantity for Remco Cough is 32 boxes since it results in a smaller shortage cost than scenario 2 with order periods every 6th and 13th. Moreover, scenario 1 also succeeded in reducing the shortage cost that exists in actual conditions. The smaller shortage cost is also a consideration for choosing the final solution for OBH Combi Batuk Berdahak Jahe 100 ml, Laserin Batuk 60 ml, and Bodrexin Pilek Alergi. However, there is a trade-off on total inventory costs for each SKU where total inventory costs might be increased compared to other simulation scenarios. For instance, in Bodrexin Pilek Alergi, the final solution chosen is scenario 1, Q = 32 boxes, which has a shortage cost of Rp 308,931.90 and total inventory costs of Rp 3,340,808.36. This total inventory cost is 31% greater than the actual condition and 6% greater than scenario 2 with the order period every 21st and 26th. However, scenario 1 can reduce the shortage cost by 45% of the actual condition whereas scenario 2 only can reduce the shortage cost by 24% of the actual condition.

While on the SKU Decadryl 120 ml, scenario 1 resulted in the smallest shortage cost. Scenario 1 cannot reduce the shortage cost by 80% of the actual condition, but the total inventory cost increased almost two times the actual condition where the store objected. Therefore, scenario 1 was not chosen as the final solution. Furthermore, scenario 2 was not chosen because there was an increase in total inventory costs by 70% from the actual condition. The pharmacy wants if there is an increase in total inventory costs of around 30-35%. Thus, analysis again on variation Q in scenario 1 and variation P in scenario 2 is performed. After tracing, all variations of Q in scenario 1 and P in scenario 2 were able to reduce the shortage cost from the actual condition. However, scenario 2 where P = 23 and 28 also P = 25 and 30 has an increase in total inventory costs of 62% and 49% of the actual condition. Then, in scenario 1 where Q = 28 boxes resulted in total inventory costs increasing by 66% from the actual condition. Hence, these three options are not selected. The final solution chosen for SKU Decadryl 120 ml was Q = 36 boxes which can minimize the shortage cost by 35% and total inventory costs increased 27%.

For SKU 60 ml Bisolvon, scenario 1 with Q = 32 boxes was not selected even though this scenario can reduce the shortage cost by 37% from the actual condition. However, the trade-off on total inventory costs has increased considerably from the actual condition, which is 57%. Thus, scenario 2 was chosen as it increased its total inventory cost by 16% and can reduce shortage costs by 23%. Table 7 summarizes the final solutions of the optimal order quantity or the optimal order period of each SKU.

Table 7 The final solutions of each SKU

SKU	Inventory policy
OBH Combi Batuk Berdahak Jahe 100 ml	Q = 30 boxes
Decadryl 120 ml	Q = 36 boxes
Bisolvon 60 ml	P = 7 an 14
Laserin Batuk 60 ml	Q = 32 boxes
Bodrexin Flu Batuk Berdahak	P = 21 and 26
Bodrexin Pilek Alergi	P = 21 and 26
Remco Cough	Q = 32 boxes

This case study considers the storage capacity and the capability suppliers to supply the product. Therefore, these final conclusions have fulfilled the two requirements. For OBH Combi Batuk Berdahak Jahe 100 ml, the optimal order quantity does not the maximum capacity of 32 boxes and Pharmacy X orders it around the 1st to 13th in accordance with the supplier's ability. For Decaryl 120 ml, the optimal order quantity is equal with the maximum capacity of 36 boxes and Pharmacy X orders it around the 20th to 30th in accordance with the supplier's ability. For Bisolvon 60 ml, Pharmacy X orders it every the 7th and 13th in accordance with the supplier's ability and the number of order quantities 28 and 32 boxes which do not exceed the maximum capacities of 32 boxes. For Laserin Batuk 60 ml, the optimal order quantity is equal with the maximum capacity of 32 boxes and Pharmacy X orders it around the 2nd to 13th in accordance with the supplier's ability. For Bodrexin Flu Batuk Berdahak, Pharmacy X orders it every the 21st and 26th in accordance with the supplier's ability and the number of order quantities 8, 12, and 36 boxes which do not exceed the maximum capacities of 36 boxes. For Bodrexin Pilek Alergi, Pharmacy X orders it every the 21st and 26th in accordance with the supplier's ability and the number of order quantities 16, 20, and 36 boxes which do not exceed the maximum capacities of 36 boxes. For Remco Cough, the optimal order quantity does not the maximum capacity of 32 boxes and Pharmacy X orders it around the 1st to 14th in accordance with the supplier's ability.

5. CONCLUSION

Using a simulation scenario, compared to the actual condition, out-of-stock and lost sales problems in 7 SKUs in Pharmacy X can be solved. OBH Batuk Berdahak Jahe 100 ML SKU has an optimal order quantity of 30 boxes and a 47% reduction in shortage costs. Decadryl 120 ml SKU has an optimal order quantity of 36 boxes and a 35% reduction in shortage costs. Bisolvon 60 ml SKU has an optimal order period every 7th and 14th also a 23% reduction in shortage costs. Laserin Batuk 60 ml SKU has an optimal order quantity of 32 boxes and a 74% reduction in shortage costs. Bodrexin Flu Batuk Berdahak SKU has an optimal order period every 21st and 26th also 52% reduction in shortage costs. Bodrexin Pilek Alergi SKU has an optimal order quantity of 32 boxes and a 45% reduction in shortage costs. Finally, Remco Cough SKU has an optimal order quantity of 32 boxes and a 40% reduction in shortage costs.

Total inventory costs rise even when shortage costs may drop from the actual condition. It is anticipated that this paper will cut overall inventory expenses by less than 30% in the future, enabling Pharmacy X to lower increasing inventory costs.

ACKNOWLEDGMENT

The authors thank to the owner of Pharmacy X for providing valuable information and time during conducting the research. This research did not receive any specific grant from funding agencies.

REFERENCES

[1] T. Khalili, A. Bidram, and J.M. Chermak, "Demand and price fluctuations effect on risk and profit of single and clustered microgrids during COVID-19 pandemic," *Electrical Power and Energy Systems*, vol. 140, 108093, 2022, doi: 10.1016/j.ijepes.2022.108093.

[2] J. Moosavi and S. Hosseini, "Simulation-based assessment of supply chain resilience with consideration of recovery strategies in the COVID-19 pandemic context," *Computers & Industrial Engineering*, vol. 160, 107593, 2021, doi: 10.1016/j.cie.2021.107593.

[3] A. Abu-Rayash and I. Dincer, "Analysis of the Electricity Demand Trends amidst the COVID-19 Coronavirus Pandemic," *Energy Research & Social Science*, (tahun) doi: 10.1016/j.erss.2020.101682.

[4] J. Feng, J. Li, W. Hu, and G. Li, "Public Interest, Risk, Trust, and Personal Protective Equipment Purchase and Usage: Face Masks Amid the COVID-19 Pandemic," *Int. J. Environ. Res. Public Health*, vol. 19, 5502, 2022, doi: 10.3390/ijerph19095502.

[5] J. Cohen and Y. van der Meulen Rodgers, "Contributing factors to personal protective equipment shortages during pandemic", *Prev. Med.,* vol. 18, 10552, 2020, doi: 10.1016/j.ypmed.2020.106263.

[6] P. Cramton, A. Ockenfels, A.E. Roth, and R.B. Wilson, "Borrow crisis tactics to get COVID-19 supplies to where they are needed," *Nature*, vol. 582, pp. 334-336, 2020, doi: 10.1038/d41586-020-01750-6.

[7] M. Kumar, R.D. Raut, M. Sharma, V.K. Choubey, and S.K. Paul, "Enablers for resilience and pandemic preparedness in food supply chain," *Operations Management Research*, vol. 15, pp. 1198-1223, 2022, doi: 10.1007/s12063-022-00272-w.

[8] P. Micheli, M. Johnson, and J. Godsell, "How the Covid-19 pandemic has affected, and will affect, operations and supply chain management research and practice," *International Journal of Operations & Production Management,* vol. 41, no. 6, pp. 773-780, 2021, doi: 10.1108/IJOPM-06-2021-902.

[9] P. Tavakol, B. Nahavandi, and M. Homayounfar, "A Dynamics Approach for Modeling Inventory Fluctuations of the Pharmaceutical Supply Chain in COVID 19 Pandemic," *Journal of Optimization in Industrial Engineering,* vol. 16, no. 1, pp. 105-118, 2023, doi: 10.22094/JOIE.2023.1966193.1981.

[10] S.A. Khiavi and S.S. Dastghiri, "The Design of Inverse Network DEA Model for Measuring the Bullship Effect in Supply Chain with Uncertain Demands," *Journal of Optimization in Industrial Engineering*, vol. 41, no. 1, pp. 93-104, 2021, doi: 10.22094/joie.2020.1885077.1703.

[11] E. Pastore, A. Alfieri, and G. Zotteri, "An empirical investigation on the antecedents of the bullwhip effect: Evidence from the spare parts industry," *International of Production Economics,* vol. 209, pp. 121-133, doi: 10.1016/j.ijpe.2017.08.029.

[12] C. Canyakmaz, O. Suleyman, and F. Karaesmen, "An inventory model where customer demand is dependent on a stochastic price process," *International Journal of Production Economics*, vol. 212, pp. 139-152, 2019, doi: 10.1016/j.ijpe.2019.01.039.

[13] G. Chen, Y. Zhao, and B. Su, "Raw material inventory optimization for MTO enterprises under price fluctuations," *Journal of Discrete Mathematical Sciences and Cryptography,* vol. 20, no. 1, pp. 255-270, 2017, doi: 10.1080/09720529.2016.1178930.

[14] A.C. Radasanu, "Inventory management, service level, and safety stock," *Journal of Public Administration, Finance, and Law*, vol. 9, pp. 145-153, 2016.

[15] C. Muriana, "An EOQ model for perishable products with fixed shelf life under stochastic demand conditions," *European Journal of Operational Research,* vol. 239, no. 3, pp. 1-20, 2016, doi: http://dx.doi.org/10.1016/j.ejor.2016.04.036.

[16] C. Kouki, Z. Jemai, and S. Minner, “A lost sales (r, Q) inventory control model for perishables with fixed lifetime and lead time,” *Int. J. Production Economics: Manufacturing Systems, Strategy, & Design,* doi: 10.1016/j.ijpe.2015.06.010.

[17] K. Govindan, “The optimal replenishment policy for time-varying stochastic demand under Vendor managed inventory,” *European Journal of Operational Research,* vol. 239, no. 3, 2014, doi: 10.1016/j.ejor.2014.09.045.

[18] R. Uthayakumar and S.K. Karuppasamy, “An EOQ model for deteriorating items with different types of time-varying demand in healthcare industries,” *The Journal of Analysis*, vol. 27, pp. 3-18, 2019, doi: 10.1007/s41478-018-0100-y.

[19] W. Paluch, “The use of the EOQ model in inventory management in the supply chain on the example of Bahlsen Polska,” *Logistics and Transport,* vol. 43, pp. 41-46, 2019, doi: 10.26411/83-1734-2015-3-43-5-19.

[20] N. Nemtajela and C. Mbohwa, “Relationship between inventory management and uncertain demand for fast moving consumer goods organisations,” in 14th Global Conference on Sustainable Manufacturing, 3-5 October 2016, Stellenbosch, South Africa [online].

[21] W.A.P. Dania, S.A. Mustaniroh, and A. Primasari, “Probabilistic economic order quantity (EOQ) for the flour inventory control (case study in Company Z),” in Proceedings of the 3rd International Conference on Digital Technology in Education, 25-27 October 2019, Yamanashi, Japan, Association for Computing Machinery, New York, United States [online].

[22] C. Chuang and C. Chiang, “Dynamic and stochastic behavior of coefficient of demand uncertainty incorporated EOQ variables: An application in finished-goods inventory from General Motors’ Dealerships,” *Intern. Journal of Production Economics*, vol. 172, pp. 95-109, 2016, doi: 10.1016/j.ijpe.2015.10.019.

[23] M. Kholil, I. Almahdya. A. Fortinina, A. Suparno, “Implementation of continuous review system method, periodic review system method and min-max method for cheese powder inventory (Case study: PT Mayora Indah TBK),” *International Journal of Advanced Technology in Mechanical, Mechatronics and Materials (IJATEC)*, vol. 01, no. 2, pp. 45-49, 2020, doi: https://doi.org/10.37869/ijatec.v1i2.16.

[24] B. Sezen, “Changes in performance under various lengths of review periods in a periodic review inventory control system with lost sales: A simulation study,” *International Journal of Physical Distribution & Logistics Management,* vol. 36, no. 5, pp. 360-372, 2006, doi: 10.1108/09600030610676240.

[25] G. Nenes, S. Panagiotidou, and G. Tagaras, “Inventory management of multiple items with irregular demand: A case study,” *European Journal of Operational Research,* vol. 205, pp. 313-324, 2010, doi: 10.1016/j.ejor.2009.12.022.

[26] S.G. Johansen and R.M. Hill, “The (r, Q) control of periodic-review inventory system with continuous demand and lost sales,” *Int. J. Production Economics*, vol. 68, pp. 279-286, 2000, doi: 10.1016/S0925-5273(00)00051-7.