Performance evaluation of vendor managed inventory variables in hospitals using ANOVA technique

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Abstract: In today's competitive market, service industry increases its scale to provide affordable and quality services to the customers. In supply chain there are various techniques and tools that can improve the output and productivity of supply chain process of a healthcare organisation. In this paper evaluation of vendor managed inventory is done by using ANOVA technique. Twenty persons from different 10–50 bedded small to medium size hospitals has been surveyed on different variables. Survey was done by personal interview and a questionnaire. That was based on the important variables of vendor managed inventory. Then mean of variables were calculated and were analysed graphically. A scattered diagram represents the variables graphically to find most and least important variables. Then ANOVA technique was applied on the variable and checked for significant value to evaluate the importance of vendor managed inventory and also analyse most and least important variable among selected.

Keywords: vendor managed inventory; VMI; inventory; ANOVA technique.

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1   Introduction

Vendor managed inventory was originated in early 1980s and retail companies were among the pioneer of the origination. (Classen et al., 2008). But now the concept has been widely spread and several industry are using this technique to get benefited from it. It is also acclaimed that vendor managed inventory (VMI) cab be the best technique to

improve performance in which the responsibility of managing the inventory has been given to suppliers or distributors (Dorling et al., 2006). Vendor managed inventory (VMI), is a continuous replenishment process that promotes information sharing and collaboration between supplier and stakeholder (Sari, 2007). The replenishment of the inventory is based on many parameters and variables among which the information sharing of inventory is foremost important. Different industries have different implementation stages of VMI. Clearly described that from total revenue of any organisation be it a retail or manufacturing, approximately 56% are spent on purchasing the goods. Also indirect cost involved is approximately 35% of the purchased goods. So it is very necessary to manage the inventory efficiently so as to make the maximum profit to the organisation. So organisations are also open up for different and efficient technique to improve the supply chain performance (Wallin and Rabinovich, 2006).

A retail industry may have different stages of VMI than that of manufacturing industry, hence the challenges and benefits are also different (Elvander et al., 2007). VMI setup not only facilitate buyer but also provides number of benefits for supplier as well. In a well-managed setting of VMI, supplier has freedom of inventory planning and replenishment scheduling as per the real time information (Classen et al., 2008).

Although many industries got benefited from VMI implementation, still hospitals and healthcare industry didn't explore this concept to the core due to their own specific nature. Indian hospitals will be growing with a tremendous pace and according to a report by Delloitte consulting; hospitals will attract the investment of approx. US$ 5 billion through FDI. Keeping all the point in consideration, the processes and services of the hospital industry need to be more efficient in order to serve the customers better. Literature review will discuss the work done on VMI in different industries and in hospital industries.

This paper is an approach to measure and evaluate the VMI effectiveness and efficiency in Indian hospital setup. At first the variables are selected to and then these are measured on the scale through a questionnaire survey. The questionnaire survey leads to finding the mean of the observation which further helps in formulation the graphical representation of the variables. Then application of ANOVA technique will finally leads to the conclusion of the study that is to found the most and least important variable of VMI among the selected ones. Table 1 shows the list of variables selected for the study.

Table 1 Vendor managed inventory variables to identify the least important and most important variable

Information sharing	It is one of the important aspects of VMI without which VMI process cannot takes place. It is the transfer of data and can be in the form of numerical data or in the form of instructions.
Collaboration	It is a form of partnership between buyer and supplier.
Turn-around time	The time between raising a requirement till delivery of that product.
Order filling rate	Order filling rate is the percentage of fulfilment of requirements of end users.
Lead time	This is the total time taken by all the operations of the supply chain process from initiation point to end point.
Accuracy	It is the precision of the required product. It explains the correctness of the product.

Table 1   Vendor managed inventory variables to identify the least important and most important variable (continued)

Number of stock outs	It is total number of requirements that are not fulfilled and can lead to dissatisfaction of customer.
Over stocking	It the surplus of inventory that can creates large number unused and non-moving products.
End user satisfaction	The satisfaction that a user get when receiving right product at right time and at right place.
Vendor satisfaction	The supplier should also be benefited from VMI process as it is a both way process. So the satisfaction gained by supplier from the benefits of VMI is vendor/supplier satisfaction.
Role of ICT (information, communication and technology)	The technology, software, internet and other tools that can help in facilitating the VMI process are very important.
Standardisation of products	One kind of product may have various brands and variety that creates the inventory burden and over stocking. So standardisation of the product is one of the important variables of VMI.
Inventory holding cost	This cost is one of the important financial burdens on any king of organisation. This cost can be increased by over stocking and manual works.
Manpower's cost	This cost is also one of the important costs as manual working not only leads to chances of error but also can increase the financial burden on the organisation by having more manpower.
Trust	This is one of the most important variables of VMI as without trust, VMI cannot takes place. VMI need to have sharing of data and any organisation can share the data only when there will trust between buyer and supplier.

2   Literature review

Importance of supply chain management in healthcare industries is increasing due to rapid increase in market growth (Antoinette and Hyland, 2015). In this competitive scenario firms strongly compete on the basis of their supply chain (Nag et al., 2014). VMI is one such model that helps the organisation having the competitive advantage. It is a business model where buyer shares the real time information to the supplier to fulfil the inventory requirement (Yao et al., 2007). VMI was originated in early 1980s and retail companies were among the pioneer of the origination (Classen et al., 2008). But now the concept has been widely spread and several industry are using this technique to get benefited from it. VMI has various advantages , one among which is to able to determine time and quantity on the replenishment This can further helps vendor to coordinate and control day to day activities and their smooth functioning (Niknamfar, 2015). VMI model is a well-known practice in collaborating supply chain management. VMI is an old philosophy and earlier discussed by Magee in a presentation of a conceptual framework for designing (Towill and Disney, 2003). Healthcare organisations used VMI systemic network for availability optimisation and cost minimisation (Kros and Falasca, 2016).

There are various variables that can determine the success of VMI in an organisation. Selected variables have been discussed in the introduction section (Zachariassen et al., 2014). Among them one of the very important factor is information sharing (Choudhary and Shankar, 2014) discussed the value of VMI with no information sharing. Significant benefits can be realised by using VMI. There are various studies that test the efficiency of certain parameters of VMI in different industries. This study is also an attempt to find the effective variable in VMI in healthcare industry.

2.1 VMI and ANOVA technique

ANOVA test helps in establishing the relationship between variables. Researchers used ANOVA test to compare means of two dependent groups. ANOVA can be used comparing two or more groups whereas other test such as t-test is used to only compare two groups (Sow, 2014). Variables of VMI can be tested and compared the results of the groups. In this study variables considered are surveyed and then ANOVA test is applied on them. Jitender et al. (2016) carried out a study in which 20 different industries were study in reference of VMI and were compared on the basis of mean of each industry. An ANOVA test is applied to find most and least used elements of VMI across different industries. Turhan (2012) stated that in healthcare setup, right material at right time and right place is very important to improve overall efficiency of supply chain.

According to research conducted by Achabal et al. (2000) some benefits both for supplier and buyer are there in VMI process. Some of them are mentioned herewith:

Benefits of VMI for supplier/vendor:

1 It facilitates the availability of maximum brands and products of the vendor in the stores or required place.

2 It helps in balancing the demand of buyer that sometimes fluctuated due to several reasons.

3 Many times information received from buyer are inappropriate and incomplete that can leads to incomplete and incorrect supplies. VMI helps in capturing the real time information of stock and accordingly facilitate the supplier to plan the inventory.

Benefits of VMI for buyer

1 It helps buyer to have more availability of products and achieve performance target.

2 VMI enables the supply chain more precise and developed that creates lowers the cost of inventory and increases efficiency of the process.

3 Methodology

VMIs are easily and remarkably implemented in some industries such as retail industry, manufacturing industry and pharma industry whereas in some industry it is difficult to implement. Healthcare industry is one of the industries where the concept is still untouchable. In the present research papers some of the questions related to VMIs are raised, which needs to be analysed and answered in the study. The questions are:

1   Which element is the most important element of VMI.

2   Which element has least contribution towards implementation of VMI?

3   Which element makes most of the contribution toward improving the efficiency of overall supply chain process.

3.1   Research design

The design of the study is non experimental quantitative research. The research specifically involves the questionnaire survey methods in which mail survey and personal survey method is used. Managers and supply chain professional gave response to the survey in this study.

3.2   Sampling method

In the present paper sampling method that is chosen to conduct the survey to collect the data is stratified sampling method. Response from strata of supply chain professionals and managers has been taken.

3.3   Research instrument

Survey used in the research is used to find out various parameters of VMI such as benefits of VMI, barriers of VMI, facilitator of VMI, Knowledge and information sharing of VMI, Readiness and others that helps in evaluating the element that is most important and least important in improving supply chain performance.

3.4   Survey participants

Responses for survey have been taken from supply chain profession from 20 hospitals. This includes supply chain manager, logistic and distribution manager, warehouse professional and purchase manager.

3.5   Data analysis

Data is analysed with the help of ANOVA technique. This technique is used in the study because this can help in analysing the results where more than two variables of population are need to compare in respect to each other.

4   ANOVA model and steps

ANOVA can be used comparing two or more groups whereas other test such as t-test is used to only compare two groups (Sow, 2014). Below listed steps will elaborate the model further:

4.1 Variable selection

In this step variable or elements of process are selected which are then evaluated on the basis of their performance. Most and least fitted variable is found out to increase the efficiency of that process. In this study variables selected are;

Information sharing, collaboration, turn-around time, order filling rate, lead time, accuracy, number of stock outs, over stocking, end user satisfaction, vendor satisfaction, role of ICT (information, communication and technology), standardisation of products, inventory holding cost, manpower's cost and trust.

4.2 Each sample mean

A sample is a small part of a whole whereas mean is a form of average. Sampling is a useful technique to find the estimate of what a whole population is doing. Obtaining mean of each sample is an important step of analysing the ANOVA results. Formula for obtaining a mean of each sample is written under. Obtain mean of each sample:

$$\bar{X}_1, \bar{X}_2, \bar{X}_3, \bar{X}_4, \ldots\ldots, \bar{X}_n$$

where there are n no. of samples.

4.3 Sample mean

In this step after obtaining mean of each sample, we will find total mean of the entire sample's mean. This is average of all the means of samples that were calculated in above step.

$$\bar{\bar{X}} = \frac{\bar{X}_1 + \bar{X}_2 + \bar{X}_3 + \bar{X}_4 + \ldots\ldots, \bar{X}_n}{No.\,of\,samples\,(n)}$$

4.4 Variance square

In this step deviation of the sample means are calculated and square of the deviations had calculated by multiplying with the number of items in the corresponding sample. Then total of the samples are obtained. These values are known as sum of squares for variance between the samples.

Symbolically, it is written as:

$$SS\,between = k_1\left(\bar{X}_1 - \bar{\bar{X}}\right)^2 + k_2\left(\bar{X}_2 - \bar{\bar{X}}\right)^2 + k_n\left(\bar{X}_n - \bar{\bar{X}}\right)^2$$

4.5 Variance or mean square

Variance is the measure of deviation from mean. In this step the result obtained in above step is divided by variance or mean square between samples (MS)

$$\text{MS between} = \frac{SS\ between}{N-1}$$

where $N - 1$ represents the degree of freedom (d.f) between samples.

4.6   Sum of square of variance within sample

This step represents the calculation of deviation value of sample items from corresponding means of the samples, then calculation of square of each deviation and obtain their total. This total is known as sum of square of variance of samples within:

$$\text{SS WITHIN} = \sum \left(X_1 - \bar{X}_1\right)^2 + \sum \left(X_2 - \bar{X}_2\right)^2 + \ldots\ldots + \sum \left(X_n - \bar{X}_n\right)^2$$

4.7   Obtaining variance or square of means

Variance or square of means will be obtained in this step by dividing SS between degree of freedom within samples:

$$\text{MS within} = \frac{SS\ Within}{(k-n)}$$

where $(k - n)$ represents degree of freedom within samples.

k is the total no. of items in the sample

n is the total no. of samples.

4.8   Calculating SS total

$$\text{SS Total} = \text{SS Between} + \text{SS Within}$$

The degree of freedom for total variance will be equal to the number of items in all samples minus one, i.e., $(k - 1)$. The degree of freedom for between and within must add up to degree of freedom for total variance, i.e.,

$$n - 1 = k - 1 + n - k$$

4.9   F-ratio

In the last step we will calculate F-ratio in which Ms between will be decided with MS within

$$\text{F Ratio} = \frac{MS\ Between}{MS\ Within}$$

The F-ratio pays its significant role in determining whether the difference among several means is valid or not. F-values which are given in table are looked for given degree of freedom at different significance level. If the calculated F-value is more than that of tabular F-value then the difference of means are insignificant whereas if the calculated

F-value less than the tabular F-value than the difference is considered as significant. The lesser the calculated F-value from tabular F-value, the more concrete is the conclusion.

5 Data analysis

From Table 2, we will be able to understand the average of importance for different variables. Sum was calculated for each variable from the collected data and average of each variable was then calculated. This helps us to understand the importance and again the average of all averages was calculated to as to find the F-ratio.

Table 2 ANOVA elements averages showing analysis of degree of importance

Sr. no.	Groups	Count	Sum	Averages	Average of averages
1	Information sharing	20	73	3.65	2.98
2	Collaboration	20	43	2.15	
3	Turn around time	20	57	2.85	
4	Order filling rate (OFR)	20	52	2.6	
5	Lead time	20	69	3.45	
6	Accuracy	20	49	2.45	
7	No. of stock outs	20	48	2.4	
8	Over stocking	20	35	1.75	
9	End user satisfaction	20	71	3.55	
10	Vendor satisfaction	20	58	2.9	
11	Role of information, communication and technology (ICT)	20	79	3.95	
12	Product standardisation	20	44	2.2	
13	Inventory holding cost	20	53	2.65	
14	Manpower cost	20	73	3.65	
15	Trust	20	91	4.55	

From Table 3, we can say that F-critical is more than the F-calculated value. So we can say that the values of elements are significant.

Table 3 F-ratio table to show the MS between the group and within the group as well as MS between and within the group

Source of variation	S.S	d.f	MS	F-ratio	10% F-limit
Between the groups	9.16	Df-1 = 14	0.65	0.91	4.636
Within groups	201.705	Df-2 = 5	0.72		
Total	210.86				

Table 4 is showing the variables that are easy to implement and also that are difficult to implement on the scale of 0–50. The variables that are above 50 on the scale are easy to implement that is these variables are easily implemented or will be implemented easily in

the opinion survey. On the other hand, those variables that are below the scale of 50 are difficult to implement in the opinion survey.

This scatter diagram is a graphical representation of Table 4 which shows that the variable with score of 91 is most difficult while implementing the VMI whereas the variable with score 35 is comparatively easy to achieve.

Table 4   Table showing the variables that are easy and difficult to implement in VMI process

Variables that are difficult to implement		Variables that are easy to implement	
Information sharing	73	Collaboration	43
Turn around time	57	Accuracy	49
Order filling rate (OFR)	52	No. of stock outs	48
Lead time	69	Over stocking	35
End user satisfaction	71	Product standardisation	44
Vendor satisfaction	58		
Role of information, communication and technology (ICT)	79		
Inventory holding cost	53		
Manpower cost	73		
Trust	91		

Figure 1   XY scatter diagram showing the variables that are easy and difficult to implement in VMI (see online version for colours)
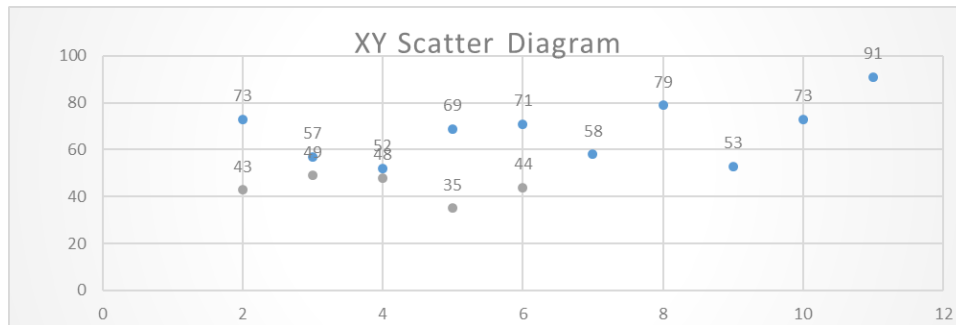
6   Discussion

Table 4 and scatter diagram, it is shown that F-critical value is more than F-calculated value. This shows that the values of elements taken for the study are significant. Also, Table 4 shows the different categorisation of elements that are difficult to implement and that are easy to implement.

All the above analysis supports the fact that implementation of VMI in any organisation depends on several factors and among those factors, some factors are easy to implement and some are difficult to implement.

7 Conclusions

The analysis done in the research is one way ANOVA analysis which shows that F-critical value is more than that of F-calculated value. This further show the significance of the variables selected for the study. This significance proves that our objective of research is significant which is saying that across all the variable of VMI, there are some variables that are difficult to implement and there are some which are easy to implement.

Further, it is clear from Table 4, that which are the variables that are easy to achieve and which are difficult while implementing the VMI. This analysis is also shown with the help of a scatter diagram. This table shows that trust with score of 91 is most difficult to achieve while implementing the VMI and other most difficult variable is role of ICT. The easy variable to achieve in the case of VMI is to control over stocking and to find a partner to collaborate in implementing VMI.

8 Scope of future research

This study is based on improving the supply chain process through the integration of a competitive technique which is known as 'Vendor managed inventory'. But some other important aspects are not covered and included in the study that could be focused in the future studies. As structure of healthcare industry is completely different and viable than other industries, so the difference and criticality should be highlighted that would further help the assessment of the feasibility of VMI in healthcare setup. Also categorisation of the material should be done before applying this technique to the healthcare organisation as all material cannot be included in this process because of the nature of urgency and criticality of material in any healthcare organisation or hospital. These few points should also be studied and analysed that will make the pillar of the further implementation of VMI.

9 Gap analysis

From literature review, it was shown that there were several studies conducted by implication of VMI in several industries but there were very less literature is available in context of healthcare industry. Especially in Indian healthcare industry, it was either very less implied or not implied. This gap makes the concept and origin of this study that will not only highlights the importance of an important technique which is known as VMI but also shows and analyse its implication in healthcare and hospital industry.

References

Achabal, D.D., Mcintyre, S.H., Smith, S.A. and Kalyanam, K. (2000) 'Decision support system for vendor managed inventory', *Journal of Retailing*, Vol. 76, No. 4, pp.430–454.

Antoinette, C. and Hyland, S.P. (2015) 'A decade of supply chain collaboration and directions for future research', *Supply Chain Management: An International Journal*, Vol. 20, No. 6, pp.613–630.

Choudhary, D. and Shankar, R. (2014) 'The value of VMI beyond information sharing under time-varying stochastic demand', *International Journal of Production Research*, Vol. 53, No. 5, pp.1–15.

Classen, M.J., Weele, A.J. and Raaij, E.M. (2008) 'Performance outcomes and success factors of vendor managed inventory (VMI)', *Supply Chain Management: An International Journal*, Vol. 13, No. 6, pp.406–414.

Dorling, K., Scott, J. and Deakins, E. (2006) 'Determinants of successful vendor managed inventory relationships in oligopoly industries', *International Journal of Physical Distribution and Logistics Management*, Vol. 36, No. 3, pp.176–191.

Elvander, M.S., Sarpola, S. and Mattson, S-A. (2007) 'Framework for characterizing the design of VMI systems', *International Journal of Physical Distribution and Logistics Management*, Vol. 37, No. 10, pp.782–798.

Jitender, Kumar, S.V. and Parteek (2016) 'Analysis of vendor managed inventory system element using ANOVA method: a case study', *International Journal of All Research Education and Scientific Methods*, Vol. 4, No. 7, pp.16–24, ISSN: 2455-6211.

Kros, J. and Falasca, M. (2016) 'Success factors and performance outcomes of healthcare industrial vending systems: an empirical analysis', *Technological Forecasting and Social Change*, Vol. 126, pp.315–345.

Nag, B., Han, C. and Yao, D-Q. (2014) 'Mapping supply chain strategy: an industry analysis', *Journal of Manufacturing Technology Management*, Vol. 25, No. 3, pp.351–370.

Niknamfar, A.H. (2015) 'Multi-objective production-distribution planning based on vendor-managed inventory strategy in a supply chain', *Industrial Management and Data Systems*, Vol. 115, No. 6, pp.1086–1112.

Sari, K. (2007) 'Exploring the benefits of vendor managed inventory', *International Journal of Physical Distribution and Logistics Management*, Vol. 37, No. 7, pp.529–545.

Sow, M.T. (2014) 'Using ANOVA to examine the relationship between safety and security and human development', *Journal of International Business and Economics*, Vol. 2, No. 4, pp.101–106.

Towill, D. and Disney, S. (2003) 'Vendor-managed inventory and bullwhip reduction in a two-level supply chain', *International Journal of Operations and Production Management*, Vol. 23, No. 6, pp.625–651.

Turhan, S. (2012) 'A non traditional vendor managed inventory: a service oriented based supply chain modelling in healthcare services', *Conference on Industrial Engineering and Operations Management*, IEOM Society, Istanbul, Turkey, p.10.

Wallin, R.C. and Rabinovich, E.M. (2006) 'What is 'right' inventory management approach for a purchased item', *International Journal of Operation and Production Management*, Vol. 26, No. 1, pp.50–68.

Yao, Y., Evers, P. and Dresner, M. (2007) 'Supply chain integration in vendor managed inventory', *Decision Support System*, Vol. 43, No. 2, pp.56–64.

Zachariassen, F., Henning, D. and Burklan, S. (2014) 'Vendor managed inventory: why you need to talk to supplier', *Journal of Industrial Engineering and Management*, Vol. 7, No. 4, pp.2–3.