

MAINTENANCE INVENTORY MANAGEMENT IN THE HEALTHCARE FACILITIES IN SRI LANKA: A STUDY ON CURRENT ISSUES AND POSSIBLE IMPROVEMENTS

A.S. Edirisingha¹, F.S. Nazeer² and A.M.L. De Alwis³

ABSTRACT

Effective inventory management in any organisation is essential as it aids in keeping organisational resources under control while managing time and expenses to enable efficient operations of facilities. Inventory management in maintenance management is crucial as this service is found to be essential to streamline maintenance management activities effectively. However, maintenance management in healthcare facilities is considered a top critical function as it has to maintain and ensure patients' quality of life and life safety. Hence, to have smooth maintenance management, well-performing maintenance inventory management is required. Accordingly, this study aims to evaluate current maintenance inventory management practices in healthcare facilities in Sri Lanka to uplift the practices by identifying the current context. A qualitative research approach was adopted. The three case studies were conducted with semi-structured interviews with three professionals in healthcare facilities. The findings of case studies present existing issues in maintenance inventory management such as unpredictable demand, high administrative expenses, lack of awareness of inventory handling, lack of support from management, hiding slow-moving items, and quality issues. The study will emphasise the possible improvements that can be implemented to overcome those identified issues, particularly for healthcare facilities.

Keywords: *Healthcare Facilities; Improvements; Issues; Maintenance Inventory Management.*

1. INTRODUCTION

Effective maintenance has a significant impact on a company's success such as keeping operations stable, reducing the likelihood of unplanned downtime, improve reliability and availability (Chen et al., 2017). Maintenance management involves a wide range of operations and functions, and it can be defined as the effective and efficient use of resources to guarantee that the process and its facilities are kept operational to the standards demanded by the users (Oliveira et al., 2012). Similarly, maintenance

¹ Undegraduate, Department of Building Economics, University of Moratuwa, Sri Lanka, achinies97@gmail.com

² Lecturer, Department of Facilities Management, University of Moratuwa, Sri Lanka, shabrinan@uom.lk

³ Lecturer, Department of Facilities Management, University of Moratuwa, Sri Lanka, madinia@uom.lk

management consists of managing mechanical, electrical, and plumbing (MEP) systems, monitoring quality assurance, and maintaining operational efficiency and workplace safety (Dhillon, 2002).

If there is a fault in the maintenance procedure, the organisation cannot continue its core business. Especially, maintenance is crucial for healthcare facilities as it ensures the smooth operation and continuity of services, including emergencies and lifesaving care (Olanrewaju et al., 2018; Yousefli et al., 2017). Furthermore, maintenance management in healthcare facilities ensures that improved productivity results in safer and more dependable equipment, lower service costs, fewer equipment outages, increased income, and more efficient use of labour within the facility (Kihiu et al., 2012).

Since maintenance and inventory management are strongly connected, inventory management is crucial for an efficient maintenance management system (Bousdekis et al., 2017). Further, it was revealed that maintenance inventory is one of the most important factors for the proper maintenance management system and it causes to avoid unnecessary costs and time wastage. The goal of maintenance inventory management is to have the proper inventory in the right quantities on hand to repair or improve assets, while also taking into account the budgets and storeroom spaces (Bousdekis et al., 2017).

When it comes to healthcare facilities, maintenance inventory is one of the major inventory types (Yousefli et al., 2017). The author further revealed that it is important to have a well-maintained structure for maintenance inventory management to ensure operational quality. Therefore, it is important to have a systematic and well-structured approach to the maintenance inventory handling process. Celebi et al., (2008) stated spare component inventories are frequently handled if at all, using generic inventory management methods, with little attention devoted to controlling characteristics unique to spare parts. Furthermore, control is typically centred on local inventories rather than the entire supply chain. According to the authors, it is clear most organisations do not pay much attention to the maintenance of inventory management systems.

In the Sri Lankan context, most studies have been done regarding medical equipment inventories of healthcare facilities. Some of those are, Dasanayka (2001) researched medical equipment performance in Sri Lankan public sector hospitals and Jayawardena (2017) conducted a study on hospital equipment management in Sri Lanka. But, there is a lack of studies on the maintenance inventory management in healthcare facilities in Sri Lanka. Accordingly, the study aims to investigate the current maintenance inventory management practices in healthcare facilities in Sri Lanka. The supportive research objectives are:

- O1: Review the concepts of maintenance management, and inventory management concerning healthcare facilities.*
- O2: Identify the current maintenance inventory management practices that are adapted in the healthcare facilities in Sri Lanka.*
- O3: Identify the existing issues and possible improvements that need to be done to ensure the successful performance of maintenance inventory management in the healthcare facilities in Sri Lanka.*

2. LITERATURE REVIEW

This section reviews literature on inventory management, maintenance inventory, maintenance inventory management techniques, maintenance inventory for healthcare facilities and potential issues of maintenance inventory handling process.

2.1 INVENTORY MANAGEMENT

2.1.1 Inventory Management Procedure

Priniotakis and Argyropoulos (2018) stated that there are four primary types of inventories: raw material, work-in-progress, finished goods, and maintenance, repair, and operating. As expressed by Singh and Verma (2018), the inventory management process includes planning, managing, and regulating inventory to minimise the investment in inventory while balancing supply and demand. Bose (2006) mentioned that a proper inventory management process involves rationalising the stocks and it can result in sizable savings a scientific system of control can significantly lower the investment in inventory, often by as much as 50% or even more.

2.1.2 Inventory Management Techniques

Gordon and Gupte (2016b) stated monitoring the supply, storage, and accessibility of goods is known as inventory management. The author further mentioned this is done to make sure there is a sufficient supply without going overboard. Different inventory management techniques can be listed as ABC Analysis, Vendor Managed Inventory, Inventory Turnover Ratio (ITR) and Re-Order Point (ROP) (Gordon & Gupte, 2016a; Priniotakis & Argyropoulos, 2018).

ABC Analysis: Nabais (2010) stated ABC analysis is an inventory management and control system which helps support inventory storage because it offers an appropriate layout for the central warehouse, which facilitates material flows and picking. Wild (2017) stated that in the ABC method, the stock is divided into three categories according to value and turnover.

Further to the author:

- A = 10 % of stock numbers, giving 65 % of turnover,
- B = 20 % of stock numbers, giving 25 % of turnover, and
- C = 70 % of stock numbers, giving 10 % of turnover.

Vendor-Managed Inventory (VMI): Gordon and Gupte (2016b) stated VMI system enables the vendor to plan, monitor, and control inventory for their clients. As ordering responsibilities are transferred to the vendor, people who were directly involved in the ordering process can then transfer their duties to customer services and special order treatments (Gronalt & Rauch, 2008).

Inventory Turnover Ratio (ITR): Rao and Rao (2009) stated inventory turnover is a vital performance indicator for determining how well inventory management is working. Gordon & Gupte (2016a) cited ITR can be defined as a cost- and inventory-minimisation strategy. There are four inventory types under ITR, Slow Moving Inventory (SMIs), Dormant Inventories (DIs), Obsolete Inventories (OIs) and Fast-Moving Inventories (FMIs). Further, it was revealed, ITR is calculated as shown in E.q. 01:

$$\text{ITR} = \text{Materials consumed cost} / \text{Average amount of inventory held over time} \dots (\text{Eq. 01})$$

Reorder point (ROP): Priniotakis and Argyropoulos (2018) stated inventory replenishment is started using the Re-Order Point (ROP) approach based on inventory level. Further, as revealed, the ROP is set at a level determined by adding a safety stock to the anticipated demand for the replenishment period, as in the equation (Eq. 02):

$$ROP = D \times LT + SS \dots \text{(Eq. 02)}$$

Where:

D = The average forecasted demand

LT = The average Lead Time

SS = The Safety Stock

2.2 MAINTENANCE INVENTORY

The maintenance tasks greatly rely on the availability of supplies such as lubricants, valves, pipe fittings, paints, angle and channel iron, controllers, and nuts and bolts for machinery and manufacturing equipment (Dhillon, 2002). The author further claims that such objects should be maintained properly to lower maintenance costs, minimise downtime for staff and equipment, and increase output. Hence as observed, controlling inventory is crucial to maintenance. To manage maintenance inventory properly, there should be a correct inventory management approach. In some cases, maintenance-related spare parts inventories are distinct from typical industrial inventories (Celebi et al., 2008). As further explained by the author, the maintenance strategies determine the demand for spare parts inventories rather than consumer consumption.

2.3 MAINTENANCE INVENTORY MANAGEMENT TECHNIQUES

The appropriate inventory management techniques for maintenance inventory handling should depend on the maintenance policies or maintenance techniques of the organisation (Celebi et al., 2008). For preventive maintenance, it may be possible to order parts that arrive just in time for usage, and it may not be necessary to stockpile repair components at all (Ahamad et al., 2011). Further for unplanned maintenance, it is necessary to keep safety stock for sudden failures. Antosz and Ratnayake (2016) described that spare components are kept in storage to make maintenance tasks easier to complete in the case of equipment failure. But as the above author elaborated, many organisations face the problem of maintaining a significant number of obsolete spare parts in stocks, resulting in excessively high storage costs. Table 1 presents the maintenance inventory management techniques which were proposed by different authors.

Table 1: Maintenance inventory management techniques

Maintenance Inventory Management Techniques	Source
Hybrid approach	(Muniz et al., 2021)
Re-order point method	(Porras & Dekker, 2008)
System-oriented inventory model	(Basten & van Houtum, 2014)
ABC classification technique	(Prachuabsupakij, 2019)

2.4 MAINTENANCE INVENTORY FOR HEALTHCARE FACILITIES

Vich et al. (2009) stated that maintenance inventory is a critical factor in the healthcare sector, to achieve maximum availability, minimal downtime, and proper response to vital components of the installations and medical equipment. It becomes necessary to optimise

the storable spare parts. The maintenance spare part classification of the healthcare facility is presented in Figure 1.

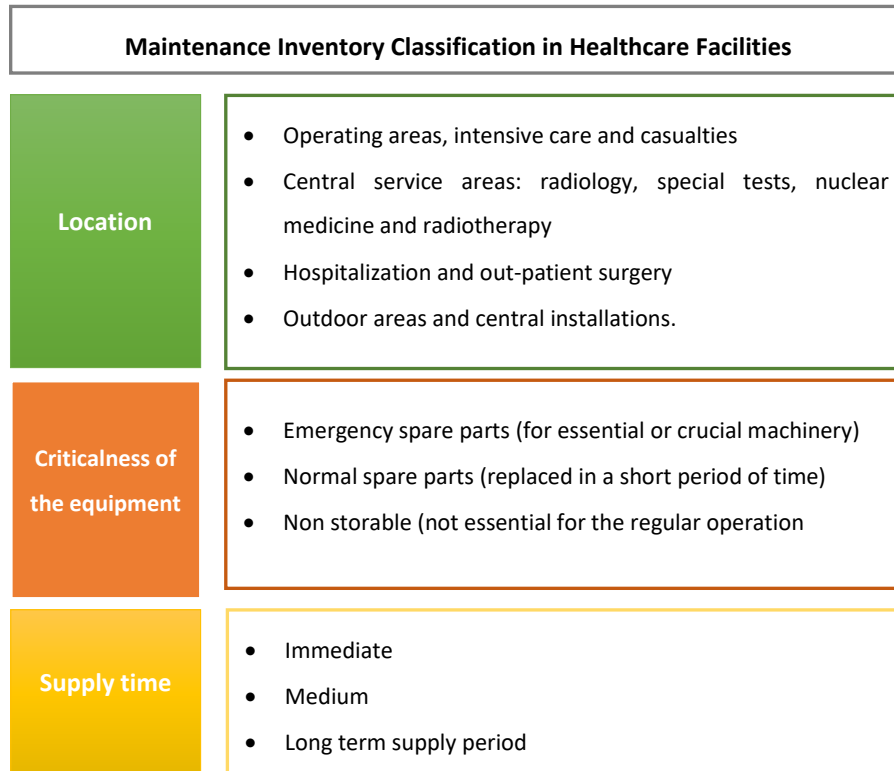


Figure 1: Maintenance inventory classification in a healthcare facility

2.5 POTENTIAL ISSUES OF MAINTENANCE INVENTORY HANDLING PROCESS

Zhang et al. (2021) stated managing the maintenance inventory is crucial to ensuring that the required item is available at the lowest possible economic and environmental cost. The author further contends the management of spare parts faces several issues due to the large number and variety of spare parts and the intermittent demand patterns that are common among spare parts. In addition, it is challenging to predict the relationship between the consumption of spare parts the product usage, the number of damages, and the maintenance required. As a whole, the issues in maintenance inventory handling are unpredictable demand, significant administrative expenses, hidden slow-moving items, quality issues, lack of awareness of people who handle the inventory and the lack of support from management (Zhang et al., 2021; Baluch et al., 2013).

3. RESEARCH METHODOLOGY

A comprehensive literature review was developed by addressing maintenance management, maintenance practices in the healthcare facilities, maintenance inventory in the healthcare facilities and inventory management techniques in the healthcare facilities. Draper (2004) stated qualitative research typically begins with "what," "how," and "why" questions rather than "how much" or "how many" questions. Further, it also looks at the answers each person gives to these questions in the context of their meanings and interpretations. The qualitative research approach was selected as suitable approach since the research problem of the study is "What are the current maintenance inventory

management practices, issues and possible improvements required in healthcare facilities in Sri Lanka?” The study aims to investigate the current issues and improvements required for existing maintenance inventory management systems in healthcare facilities. Hence, the case studies research method was applied under the qualitative research approach. Accordingly, three hospital facilities were selected on both medium and large scales. Because both medium and large-scale hospitals handle a considerable amount of maintenance inventories. Interviews were conducted with managerial-level respondents who are involving in maintenance inventory management in hospitals. The selection of respondents was based on purposive sampling technique. The collected data were analysed by using manual content analysis.

Table 2: Details of the selected cases

Cases	Details
Case A	Location: Gampaha District, Established year: early two thousand, Scale: Medium scale, Bed capacity: 70, In the hospital, maintenance inventories are handled by the maintenance manager and not a separate inventory management division for maintaining inventories. The maintenance manager keeps records of maintenance inventories and handles inventories as per the requirements of the hospital.
Case B	Location: Colombo District, Established year: Mid nineteen eighties, Scale: Large scale, Bed capacity: 400, In the hospital, maintenance inventories are handled by the stock division under the inventory manager. The inventory manager is the main responsible person for handling maintenance inventories.
Case C	Location: Colombo District, Established year: early two thousand, Scale: Large scale, Bed capacity: 350, The maintenance procedure of the hospital is handled by the engineering department. There is a separate stock to keep maintenance inventories which are supervised by the inventory officer.

Table 3: Profile of the respondents of the cases

Cases	Respondents	Role	Experience in years
Case A	AR	Maintenance Manager	20 years
Case B	BR	Inventory Manager	12 years
Case C	CR	Electrical and Mechanical Engineer	15 years

4. RESEARCH FINDINGS

4.1 CURRENT INVENTORY MANAGEMENT TECHNIQUES

According to responses of all three cases, reorder point technique is used by them as a maintenance inventory management strategy. But the way of determining the re-order point differs in each case. In Case of A, AR mentioned “*Re-order point is used to make new orders for maintenance inventories*”. In the case of B, BR stated “*re-order point of stock inventories have been defined. But this re-order point is not defined for all maintenance inventories*”. When it comes to Case C, CR mentioned, “*currently we used the re-order point method to determine when orders should be placed for inventories*”. That means the re-order point technique is used to handle the ordering process of maintaining inventories. But the way of deciding the re-order point is different in each case. In Case of A, reorder point is decided by the maintenance manager. AR mentioned, “*Re-order point will decide by manually checking the available number of spare parts in the inventory stock*”. In Case of B, re-order points of major stock items are entered into

a system. BR stated “Currently ordering process stock inventory is done through HIS, Hospital Information System. Here reorder point for each item is added and when the inventory level achieved the re-order point, the HIS system will indicate it. After that, place orders for new inventory stock”. In Case of C, CR mentioned “inventory officer determines the re-order point of each inventory. According to that orders are placed through the procurement department”. Thus, it is identified that re-order point is the inventory management technique currently use in maintenance inventory management processes.

4.2 ISSUES IN THE CURRENT INVENTORY MANAGEMENT PROCESS

Potential issues of the inventory management process were identified in the literature review. Those identified issues were presented to respondents of case studies to ensure their existence in practical scenarios of healthcare facilities under the context of maintenance inventory management.

Table 4: Issues in the maintenance inventory management process

Theme	Identified issues through literature	Availability in cases		
		Case A	Case B	Case C
Issues in the current inventory management process	Unpredictable demand	x		x
	High administrative expenses	x	x	x
	Lack of awareness of inventory handling		x	x
	Lack of support from management	x	x	x
	Hide slow-moving items	x		
	Quality issues	x	x	x

Unpredictable demand: Out of three cases, respondents of Cases A and C highlighted there are issues due to unpredictable demand. The respondent of Case A, AR mentioned “sometimes demand maintenance inventories vary with unexpected maintenance works. Therefore, some problems happened due to unavailability of inventories to perform sudden maintenance activities”. The respondent of Case C, CR mentioned “actually unpredictable demand is a problem. In sudden breakdowns, it is difficult to find the required spare parts in a short period. It may cause long breakdowns. To manage those situations up to some extent, some corrective actions are taken such as using repaired old spare parts or using alternative/ standby machine o equipment”. But in Case B, BR mentioned “if we considered inventory requirement department vice there are no much variations in demand. We have established plus and minus levels for inventory requirements by considering past data. Inventory demand fluctuates within these plus and minus levels if there is no special event”.

High administrative expenses: Respondents of all three cases mentioned significant amount of administrative expenses is required for the whole maintenance inventory management procedure. In Case A, AR mentioned “administrative expenses for maintenance inventory handling is high because the administrative cost associated with different stages like ordering, procurement process, and keeping at the stock”. In Case B, BR mentioned, “administrative cost may be high because organisations have to allocate a significant amount of money for the administrative cost associated with ordering, keeping, and discarding procedures of maintenance inventories”. CR also

affirmed that the administration cost of the maintenance inventory handling process is high.

Lack of awareness of maintenance inventory handling: Out of three cases, Case B and Case C have issues with a lack of awareness of persons who handle the maintenance inventory. In Case B, BR mentioned “*it is necessary to have enough technical knowledge for persons who handle the maintenance inventory to define the re-order level of inventory and decide what is the exact inventory type which is required to perform relevant maintenance activity. If not, it affects the quality of maintenance work and a usable lifetime of machinery and equipment*”. In Case C, CR mentioned, *persons who work with maintenance inventory handling should have awareness of required maintenance inventories for maintenance activities. There were some problems in our maintenance inventory handling process lack of awareness of workers and their mistakes*”. However, in the case of A, AR mentioned the opposite opinion that “*there were no issues due to a lack of awareness of people who handle the maintenance. The maintenance inventory handling process is done by the maintenance manager. The maintenance manager is responsible to determine the re-order level of inventories, keeping inventories the stock and maintaining records*”.

Lack of support from management: All respondents of Cases A, B and C mentioned they have this issue. In the case of A, AR mentioned “*lack of support from management is one of the problems in maintenance inventory management*”. BR affirmed that the top management has not had much interest in the maintenance inventory handling process within the facility. CR also agreed with AR and BR.

Hide slow-moving items: Out of three cases, the respondent of case A has this problem. In the case of A, AR mentioned, “*sometimes slow-moving items are kept a long period in the stocks. Those items may be hidden due to lack of visualisation*”. But respondents of Case B and Case C have provided opposite responses. In Case B, BR mentioned “*we maintain separate excel sheets to record information of slow-moving inventories which have warranty periods. When relevant inventory reaches the warranty period, it can be checked through an excel sheet. After reaching the warranty period, the renewal procedure is implemented. Then this problem can be avoided up to some extent and it helps to avoid problems with expiring inventories at the stock*”. In case, CR mentioned “*inventory officer maintains records of fast-moving items and slow-moving items separately. Through these records, they manually check the available amount of inventories at the stock*”.

Quality issues: All respondents mentioned there are issues with low-quality maintenance inventories. In Case A, AR mentioned “*quality is the most important factor. There are issues with low-quality inventories due to problems in the inventory supply process. There are difficulties to receive inventories with the required quality level. Because suppliers do not have exact inventory and they provide inventories with same properties but without required quality*”. Case B and Case C affirmed the response of Case A. In Case B, BR mentioned “*quality problems are raised due to limited supplier base. If the required inventory is not available in existing supplies, they provide alternative inventory which has not required quality level. In addition, in the ordering process, sometimes orders are placed without mentioning the exact brand name, serial numbers and other specifications. Then it causes to receive low-quality inventories*”. In Case C, CR

mentioned “Sometimes suppliers are not capable to provide inventories with all requirements. And also, there are difficulties finding inventories with exact quality”.

Further, it is observed, current maintenance inventory management procedures in healthcare facilities have issues which were identified in the literature review. In addition to the identified issues in the literature, respondents in some cases mentioned additional issues. AR mentioned, “there are issues with lack of accuracy in forecasting process and parts are not available when needed due to poor procurement practices and poor replenishment”. BR mentioned, “issues with inventories are not properly stored in the store room and spare part substitution”. Thus, it is identified that there are more issues in the current maintenance inventory management process.

4.3 IMPROVEMENTS THAT NEEDS TO BE MADE IN THE CURRENT INVENTORY HANDLING PROCESS

The possible improvements which are suggested by the respondents of three cases for mitigating all the identified issues are tabulated as shown in Table 5.

Table 5: Improvements for identified issues.

Identified issues	Improvements	Respondents		
		AR	BR	CR
Demand is unpredictable	• Properly analyse requirements of maintenance inventory			x
	• Keep additional inventories for emergency	x		
	• Forecast inventory requirements by considering past data		x	
High administrative expenses	• Increase the effectiveness of record keeping procedure	x		x
Lack of awareness of inventory handling	• Allocate a separate division in the supply department to handle the maintenance inventory supply process		x	
	• Invest in the training program for the person who handles maintenance inventory.			x
Lack of support from management	• Aware of the importance of the maintenance inventory handling process	x		
	• Present financial benefits of proper maintenance inventory handling process		x	x
Hide slow-moving items	• Keep records separately for all slow-moving items		x	
	• Keep slow-moving items separately in the stock			x
Quality issues	• Improve the ordering process with the indication of the exact brand and quality level		x	
	• Increase the number of suppliers who have high capabilities			x
	• Make a strong supplier base.	x		
Lack of accuracy in the forecasting process	• Documenting all receipts for components against purchase orders or outside repair orders, as well as receipts for parts that have been returned to the storage.	x		
Parts are not available when needed.	• Improve the effectiveness of the procurement process	x		
Inventories are not properly stored in the storeroom.	• Organise the storeroom, slot parts properly depending on part volume and characteristics; use ID numbers		x	

Identified issues	Improvements	Respondents		
		AR	BR	CR
Spare part substitution	• Properly place an order with all specifications.		x	

Improvements to overcome unpredictable demand: Respondents of Case A and Case B have recommended improvements to overcome the unpredictable demand for maintenance inventories. In Case A, AR mentioned, “*To overcome issues due to unpredictable demand, it is better to keep an additional amount of inventory to use in an emergency*”. The respondent of case C proposed a different opinion. CR mentioned “*the maintenance requirement of the facility should be properly analysed by comparing past demand changes. It helps to predict what are the required maintenance inventories to perform maintenance activities successfully*”.

Improvements to overcome high administrative expenses: All respondents in three cases have proposed improvements to overcome significant administrative expenses. Respondents of Case A and Case C have proposed similar improvements. According to those two respondents, they proposed to increase the effectiveness of the current record-keeping procedure. In Case A, AR mentioned, “*administrative expenses can be reduced through proper record keeping. Because it helps to avoid destroy inventories due to expiry, and ensure available inventory level*”. In Case C, CR mentioned “*proper record keeping helps to avoid unnecessary administrative expense. For that it needs a system which can record inventory information easily and frequently check the number of available inventories*”. Respondent of Case B mentioned different opinions to avoid high administrative expenses. BR mentioned “*persons should be allocated effectively for maintenance inventory handling process. It helps improve communication procedures within departments and avoid necessary expenses*”.

Improvements to overcome the lack of awareness of inventory handling: Respondents of Case B and Case C have proposed improvements to overcome the lack of awareness of people who handle the inventory. In Case B, BR mentioned “*to improve inventory ordering process, It is better to allocate separate division in the supply department to handle the maintenance inventory supply process. Then they have enough technical knowledge regarding maintenance inventories, and it helps to get correct inventories as per the requirements*”. In Case C, CR mentioned “*persons who handle maintenance inventory take important decisions regarding inventory ordering process and keeping. Therefore they should know relevant subject areas. Therefore it needs to invest in the training program for the person who handles maintenance inventory*”.

Improvements to overcome lack of support from management: All respondents in three cases have provided improvements to overcome the lack of support from management. In Case A, AR mentioned “*proper maintenance inventory handling process is important to perform maintenance activities effectively. Therefore, it is better to be aware of the importance of the maintenance inventory handling process*”. Respondents of Case B and Case C provided the same kind of improvements to overcome this issue. They have proposed to present the financial benefits of a proper maintenance inventory handling process. BR mentioned “*maintenance inventories have considerable involvement in the maintenance budget of the facility. Therefore, it is better to be aware top management regarding the importance of proper maintenance inventory management system*”. CR mentioned, “*to get the involvement of top management, it is better to be aware of management regarding financial benefits of maintenance inventory handling*”.

Improvements to overcome hiding slow-moving items: Respondent of case A has mentioned two improvements to overcome hidden slow-moving items. AR mentioned “*to avoid hiding slow-moving items in the stocks, it is better to keep separate records for all slow-moving items and keep slow-moving items separately in the stock. Then it is easy to check the amount of available slow-moving items in the stocks*”.

Improvements to overcome issues with quality: Respondents of all three cases have proposed improvements to overcome quality issues. In Case A, AR mentioned, “*to get quality inventories it is necessary to have a strong supplier base. Then inventories can be received at required quality level*”. In Case B, BR mentioned “*In the hospital, the inventory ordering process is done through HIS (Hospital Information System). In the HIS, separate codes are used to identify different inventories. But this code does not specify the exact item with its specifications. It leads to receiving items with low quality, low durability and not fitted to the maintenance work. Therefore, it is necessary to improve the current ordering process*”. In Case C, CR mentioned “*to avoid issues with low-quality inventories, it is better to Increase the number of suppliers who have high capabilities. It helps to get inventories with required quality level*”.

Accordingly, the above-identified improvements can be initiated in healthcare facilities to overcome current issues in maintenance inventory management.

5. CONCLUSIONS

The current maintenance inventory management technique of three healthcare facilities was identified as the Re-order point technique. In some cases, reorder point of maintenance inventory is determined manually and in some cases, a computerised system is used to store data about re-order levels. But there is no specific procedure to determine the re-order point. In some cases, the re-order point is determined by checking the available inventory quantity in the store and in some cases it is determined by using past consumption data and safety stock levels. Even though case study facilities implemented maintenance inventory management techniques, there were issues with their current system. In the literature review, unpredictable demand, high administrative expenses, lack of awareness of inventory handling, lack of support from management, hide slow-moving items, and quality issues were identified as possible maintenance inventory management issues in healthcare facilities. Among those issues, high administrative expenses, lack of support from management, and quality issues were identified as the top issues in the practical scenario through the case studies. In addition to the identified issues in the literature review, additional issues were mentioned by respondents of the case studies such as issues with lack of accuracy in the forecasting process, poor procurement practices, poor replenishment, issues with storage process and spare part substitution. According to the perceptions of respondents in case studies, improvements were identified for existing issues in the maintenance inventory management system. Thus, it is identified that existing maintenance inventory management in healthcare facilities should be improved for proper operation in maintenance management procedures.

6. RECOMMENDATIONS

Reis et al. (2017) stated lean management emerges as a viable alternative to improve overall operational performance in inventory management while increasing flexibility, lowering costs and decreasing lead times. Lean has been implemented in a diverse range

of organisational contexts such as operation rooms, hospital departments, hospital-based pharmacies, etc. and specialities such as emergency medicine, surgery, gastroenterology, etc. Kanban is a lean methodology that employs the pull method. It is a useful technique in a medical environment to manage different types of inventories. Accordingly, it is identified that Kanban is a suitable inventory management technique to overcome issues in the maintenance inventory handling process in healthcare facilities in Sri Lanka.

7. REFERENCES

- Ahamad, R., Kamaruddin, S., Azid, I., & Almanar, I. (2011). Maintenance management decision model for preventive maintenance strategy on production equipment. *Journal of industrial engineering international*, 7(13), pp.22-34.
- Antosz, K., & Ratnayake, R. M. C. (2016). Classification of spare parts as the element of a proper realization of the machine maintenance process and logistics-case study. *IFAC-PapersOnLine*, 49(12), pp.1389-1393.
- Gordon, S.A., & Gupte, J. (2016a). Contemporary inventory management techniques: A conceptual investigation. *Proceedings of the International Conference on Operations Management and Research*, pp.21-22.
- Gordon, S.A., & Gupte, J. (2016b). Review of modern inventory management techniques. *Global Journal of Business & Management*, 1(2), pp.1-22.
- Baluch, N. H., Abdullah, C. S., & Mohtar, S. (2013). Evaluating effective spare-parts inventory management for equipment reliability in manufacturing industries. *European Journal of Business and Management*, 5(6), pp.69-76.
- Basten, R. J. I., & van Houtum, G.-J. (2014). System-oriented inventory models for spare parts. *Surveys in Operations Research and Management Science*, 19(1), pp.34-55.
- Bose, D. C. (2006). *Inventory management*. PHI Learning Pvt. Ltd. NewDelhi
- Bousdekis, A., Papageorgiou, N., Magoutas, B., Apostolou, D., & Mentzas, G. (2017). A proactive event-driven decision model for joint equipment predictive maintenance and spare parts inventory optimization. *Procedia Cirp*, 59, pp.184-189.
- Celebi, D., Bayraktar, D., & Ozturkcan, S. (2008). Multi criteria classification for spare parts inventory. *38th Computer and Industrial Engineering Conference, October*, pp.1780-1787.
- Chen, Y., Cowling, P., Polack, F., Remde, S., & Mourdjis, P. (2017). Dynamic optimisation of preventative and corrective maintenance schedules for a large scale urban drainage system. *European Journal of Operational Research*, 257(2), pp.494-510.
- Dasanayka, S. W. (2001). Performance of health care equipment in public sector hospitals in the eye of good governance, A case study based on the Sri Lankan public sector hospitals. *International Journal of Bio-medical Engineering and Technology*, 4 (5), pp.317-342.
- Dhillon, B. S. (2002). *Engineering maintenance: a modern approach*. cRc press. Boca Raton
- Gronalt, M., & Rauch, P. (2008). Vendor managed inventory in wood processing industries-a case study. *Silva Fennica*, 42(1), 101.
- Jayawardena, D. (2017). Hospital equipment management in district base hospitals in Kalutara district in Sri Lanka. *Biomedical Statistics and Informatics*, 2(1), pp.18-21.
- Kihui, J. M., Maranga, S., & Mutia, D. (2012). Maintenance management of medical equipment in hospitals. *Industrial engineering letters*. 2(3), pp.10-19.
- Lanza-León, P., Sanchez-Ruiz, L., & Cantarero-Prieto, D. (2021). Kanban system applications in healthcare services: A literature review. *The International Journal of Health Planning and Management*, 36(6), pp.2062-2078
- Muniz, L. R., Conceicao, S. V., Rodrigues, L. F., de Freitas Almeida, J. F., & Affonso, T. B. (2021). Spare parts inventory management: a new hybrid approach. *The International Journal of Logistics Management*, 32(1), pp.40-67.
- Nabais, J. I. B. (2010). *Inventory management for the health sector: ABC analysis approach*. NSBE-UNL. Retrieved from <https://core.ac.uk/download/pdf/157627019.pdf>

- Olanrewaju, A., Fang, W. W., & Tan, Y. S. (2018). Hospital building maintenance management model. *International Journal of Engineering and Technology*, 2(29), pp.747-753.
- Oliveira, M. M., Lopes, I. da S., & Figueiredo, D. (2012). Maintenance management based on organization maturity level. *International Conference on Industrial Engineering and Operations Management*. 9-11 July, Guimaraes, Portugal.
- Porras, E., & Dekker, R. (2008). An inventory control system for spare parts at a refinery: An empirical comparison of different re-order point methods. *European Journal of Operational Research*, 184(1), pp.101-132.
- Prachuabsupakij, W. (2019). ABC Classification in spare parts for inventory management using ensemble techniques. *2019 IEEE Asia Pacific Conference on Circuits and Systems (APCCAS)*, pp.333-336.
- Priniotakis, G., & Argyropoulos, P. (2018). Inventory management concepts and techniques. *IOP Conference Series: Materials Science and Engineering*, 459(1), 12060.
- Rao, C. M., & Rao, K. P. (2009). Inventory turnover ratio as a supply chain performance measure. *Serbian Journal of Management*, 4(1), pp.41-50.
- Reis, A., Stender, G., & Maruyama, U. (2017). Internal logistics management: Brazilian warehouse best practices based on lean methodology. *International Journal of Logistics Systems and Management*, 26(3), pp.329-345.
- Singh, D., & Verma, A. (2018). Inventory management in supply chain. *Materials Today: Proceedings*, 5(2), pp.3867-3872.
- Vich, A., Gomez, A., & Carnero, M. C. (2009). Design of the system of storing administration for maintenance in a hospital. *International Journal of Applied Management Science*, 1(3), pp.277-299.
- Wild, T. (2017). *Best practice in inventory management*. Routledge. London
- Yousefli, Z., Nasiri, F., & Moselhi, O. (2017). Healthcare facilities maintenance management: a literature review. *Journal of Facilities Management*, 15(4), pp.352-375.
- Zhang, J.-X., Du, D.-B., Si, X.-S., Hu, C.-H., & Zhang, H.-W. (2021). Joint optimization of preventive maintenance and inventory management for standby systems with hybrid-deteriorating spare parts. *Reliability Engineering & System Safety*, 214, 107686.