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Decision Making in Designing a Medical Lean Maintenance Management System A Case Study for Jordanian Military Hospitals

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Abstract

Decision making of medical devices idle problems is a prime cause why health care leaders are calling to redesign health care delivery. One of the concepts used in decision making is lean thinking. There is a lack of high quality evidence supporting lean culture. The decision making of lean approach has been applied more frequently in manufacturing sector than service sector, mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment mainly because of several perceived barriers in the latter environment that have caused managers to be reluctant to make the required commitment. In this paper, we described a case where a decision making of lean principles was adapted for the process sector for application at a large integrated military medical hospital.

Key words: Decision Making; Medical Lean Maintenance Management; New Product Development (NPD).

Introduction

After World War II Japanese manufacturers were faced with vast shortages of material, financial, and human resources. These conditions resulted in the birth of the ‘‘lean’’ manufacturing concept [1].Maintenance can be defined as all activities necessary to keep system and all of its components in working order. The objective of any maintenance program should be to maintain the capability of the system. While controlling the cost and any change in a product or system from its satisfactory working condition to condition that is below the acceptable or set operating standard for the system can be defined as a failure [2].Lean thinking evolved from a tool designed to improve operational shop-floor performance at an automotive manufacturer to a management approach with both operational and socio technical aspects[3].

Literature review

Lean production not only successfully challenged the accepted health service practices in the medical industry, significantly shifting the trade-off between productivity and quality. Enaghani et al. (2009) has defined lean as a systematic approach and a combination of several techniques in order to identify and eliminate waste that leads to continuous improvement and ultimately excellent performance. Decision making of lean management is a further extension of lean thinking and involves examining organization as whole entities and giving decisions regarding managing competing and control [4]. Alan brown presented an example on studies of lean in medical field where he studied the factors that are correlated with success in new product development (NPD) is based on 68 responses to a survey of medical device companies in the UK and Ireland.

It was found that the degree of technological innovation, the involvement of end users in the development process, the dissemination of NPD priorities to staff, and the use of financial analysis throughout the development process were all correlated with success in a statistically significant manner. These findings demonstrate the importance of innovation, integration and the use of financial metrics to sustained product development success. In addition, this survey found that new-to-the world innovations made up only 4.4% of NPD projects in larger companies and 9.3% of NPD projects in small and medium sized enterprises [5]. This study tried to tackle the type of maintenance used in medical devices workshops after collecting all information about them. It aimed at decreasing the losses occurring in medical devices workshops and the reasons that lead to these losses by selecting a medical devices workshop and shedding some light on the losses that occur in it.

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The organizational hierarchy of the Institute Of Biomedical Technology (IBMT) within Royal Medical Services (RMS) has been viewed as the last reference for all regulations that are related to all specializations. After that, these decisions and consultations will be given to the IBMT. It will take its role in applying these decisions. Generally, IBMT considered as the main and direct supervisor on the medical devices in the Jordanian army. Also, it is considered as the connecting links between the military hospitals and all hospitals in Jordan regardless of its nature.

Research Methodology
Data Collection

Royal Medical Services had established multiple of military hospitals distributed all over the Jordanian regions where there is at least a military hospital in every province. These military hospitals are:

Table 1 Military hospitals in Jordan

Hospital Name	Location
Prince Rashed Bin Alhassan	Irbid
Prince Hashem Bin AlHussein	Zarqa
Queen Alia Military Hospital	Amman
Prince Ali Bin AlHussein Hospital	Karak
Prince Zeid Hospital	Tafileh
Princess Haya Hospital	Aqaba
King Hussein Medical City	Amman

Every military hospital consists of at least one workshop where they are divided according to medical devices types. Again, the information such as the regions, the number of schools and the number of the available specializations has been taken from the management of medical devices workshops especially in the laboratory departments and surgical department with assistance of the chemical engineers, laboratory technicians and Nursing staff.

After collecting this piece of information, a diagram has been designed to scan the medical devices in these workshops. These workshops include 27 different specializations in different hospitals. Some of these specializations are exclusive to certain hospitals and regions such the PET scan in King Hussein Medical City (KHMC). The medical devices paper has included much information about medical devices as shown in table 2.

Table 2 Medical devices paper

No	
Medical device code	
Medical device description	
Quantity	
Type & Serial Number	
Purchasing Date	
Criticality type	
Maintenance policy adopted	
(MTTF)	
(MTTR)	
Medical devices Shutdown Reasons	
Notes	

Description of the Questionnaire

Two professional engineers in the field of biomedical devices maintenance and chemical engineering and a professional technicians in the Medical Devices Maintenance Workshops (MDMW) have been met and agreed on the basics on which this questionnaire will be built.

A total of 600 questionnaires have been distributed among MDMW in Amman military hospitals. When designing this questionnaire, the nature of work and the nature of workshops have been taken into consideration. The questions have been asked according to the subjects that have been agreed on previously and they have been as the following:

Training: This has included the manner and nature of training, the systems adopted in training and the necessity of training.

Materials: This has included the materials offered either by the administration or the RMS from the quality of these materials and its compatibility with the international standards.

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Maintenance: this has included the frequent failure of medical devices, the guarantee given to these machines and the available methods of maintenance.

Decision Making of Lean Management:

This has included the wastes and losses in the MDMW such the over-waiting, over-movement, storing of extra materials, delivering materials, and proper people for the proper work.

Classification According To Medical Devices

After scanning the machines, a classification process has been done on two stages: classification in terms of MDMW and According to the type of medical devices.

According to MDMW

This process has been done in terms of workshops. For example, the information about the medical devices of the electricity utilization workshop has been gathered and classified in terms of broken and active medical devices. Also, another classification is According to the description of the medical devices, its number, its maintaining system, the position of the medical devices in the average time of breakdown, the average time of fixing, the broken medical devices and the time of breakdown, and is it still broken as a result of lacking in spare parts, the necessity of maintaining or from the time of bringing the medical devices to the workshop and the cause of being not operated.

Accordingly, the medical devices that work very well and the broken one should be gathered. After that, the percentage of breaking down should be calculated from the total.

The following table shows 6 workshops or specializations where the machines have been classified in terms of MDMW.

Table 3 Classification According To number of workshops and breakdown

Hospital Name	No. of Workshops	Breakdown
King Hussein Medical City	5	4250
Queen Alia Military Hospital	1	800

The medical devices have investigated by its serial numbers, name, size (small, medium, or large), the date of installation, the date of starting and operating, and the number of broken machines. 6 MDMW have been scanned, and the broken machines have been around the percentage of 6 % out of the total machines in them.

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Data Analysis

After collecting the questionnaires which have been spread to all MDMW which have been 600 questionnaires, 450 respondents have agreed to fill out the questionnaire which means 75% which is a very good percentage. The data analysis has shown the following:

Training

The trainees from engineers and technicians have occupied the highest percentage. Training is usually at the heart of specialization70 % of the respondents has said that 90 % of the training is at the heart of specialization. Also, 80 % of them have said that 75 % of the training is usually by using modern systems. Training is more common among technicians, and 50 % of the respondents have supported that.79 % of the respondents have totally agreed that training is a basic factor in increasing the skills and efficiency of the trainees.

Materials

It seems that few MDMW have the space to store materials, and the majority of workshops do not have any space to store the spare parts because of the small size of these workshops. Also, computers are not used in the inventory of materials and spare parts in the stores. In addition, they are not used in programming the maintenance, and these workshops sometimes apply the international standards on the therefore, the work is not finished within the required time. Consumed and manufactured materials are calculated in the workshop. The amount of working is also calculated during 6 months. Achieving work often happens within the required time, and 60 % of the respondents said that achieving work sometimes happens within the required time. The role of supervisors and engineers in the MDMW is an effective one through the supervision, application and quality assurance after finishing with the work.

Maintenance

In the questionnaire, it is sometimes but not always that there is enough space in stores to store the big spare parts, and also this is in some MDMW. When it comes to the machines' stops, most of the respondents have answered that most machines stop once a year and sometimes twice, but no reports are conducted about these frequent stops for the sake of maintenance. Finally, the actual working hours of the engineers and technicians reach to 60-80 % from the daily working hours.

Decision Making of Lean Management

In this section, the respondents have been asked about the wastes and losses in the engineering workshops. The highest percentage of 70-90 % in the wastes and losses has been in the over production, extra moving of materials, extra passing of materials and the unwanted teachers in the workshops. The waiting to the excess of the required rate, storing of materials, production that does not meet the standards, and the extra raw materials that can be recycled have occupied a percentage of 30-40%.

Tools of Lean in MDMW

1. 9 Wastes: according to Ohno (1912 – 1990), a Toyota executive, identified seven types of waste found in any process:
a. Transportation which is unnecessary transport of parts under production
b. Inventory which is stacks of parts waiting to be completed or finished products waiting to be shipped.
c. Motion which is unnecessary movement of people working on products.
d. Waiting which is unnecessary waiting by people to begin the next step.
e. Over-Processing which means the product with extra steps
f. Over-Production of products not needed
g. Defects in the product

h. Goods and services that do not meet the customer's needs.
i. Underutilization of people and martial and natural recourses.

2. 5-s the implementations of 5s according to Matthew are as the following:
a. Seiton which includes organization, proper and housekeeping.

b. Seiri which includes sorting and arrangement.

c. Seiso which includes sweeping, workplace and hygiene.

d. Seiketsu which includes neatness, cleaning.

e. Shitssuke which includes strictness or discipline, [2].

3. Value Stream Mapping

4. Point of Use Storage

5. Pull

6. Visual Controls

7. Mistake Proofing

All the above mentioned losses will be studied and applied in the KHMC MDMW. The number of workshops at this school which has been chosen for the study is six MDMW.

Information Required for the Study

Table 4 MDMW Technicians

No. Technicians	Avg. Experience	Avg.Salary	Avg. No. training courses
50	12	800	10

Table 5 Medical devices status

Avg. No of Medical devices	2450
Avg. No. Idle devices	150
Approximate Avg. Cost of Machines	20 Millions JD
Avg. Parching or Installation Date	2000
Age of Machines	15 years

Data Analysis

One technician can do around 0.5repair per hour. In the market one technician can do around 0.9 repairs per hour. In this study, the inventory and the motion as wastes will be discussed.

Inventory is defined as stacks of parts waiting to be completed or finished products waiting to be shipped. The main reasons for waiting are the following:

1. Bringing all materials at a time.
2. Lacking of working organization as groups and all of particular group in one phase of the work [6].

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Solutions

There are suggested solutions for the above mentioned problems as the following:

- Regulating the work in the operator as groups and each group is doing a particular work with speed and accuracy of production applying the safety rules.
- A good planning from technician and supervisors provides more accuracy, safety and fast delivery.
- Never allowing any group to sit at work in order not to accumulate the production process.

Motion

Motion is defined as unnecessary movement of people working on products. The main reasons for unnecessary movement of people working on products are as the following:

- The area in the operator does not allow people to move regularly or freely to because of the narrow space.
- The volume of work is not commensurate with the space.
- The quantity of materials at one time reduces the space and; therefore, it contributes to the movement of people irregularly or lacking of control.

Solutions

- Reducing the number of technicians to suit any available space (4 m^2) for each individual.
- Finding stores for the manufactured materials to allow the students to calculate the movement to clear the place regularly.

Cost Estimation

Cost estimation is a field that has received much attention over the years from biomedical engineers. All necessary cost information is present to allow calculating the costs accurately for sheet metal parts

Cost estimation is also a piece of evidence needs to be collect all information and correct application in the company or factory to know the size of the product compared to the size and age of machinery available, the period time remaining of the machines and the price of machinery after consumption. Also, the time period needed for improvement the machinery is necessary to indicate the situation of the factory [6].

The military hospitals are the most important sector for educated, trained and supplier of medical staff to the market. Therefore, it is advisable to study these workshops and proportional development with new technology in industrial field. This report contains necessary and very important information in order to see clearly fact of workshop and what is required of us to do.

Information Requirements

The aim of the knowledge of the size of these workshops is by knowing the price of these machines and determines the proportion losses and the situation of these medical devices.

1. Avg .all machines working and idle 20 million JD
2. Unneeded machines 35,000 JD
3. Unused machines 25,500 JD
4. Idle machines 700,000 JD

The rate of actually working machinery is 96.5% and idle machinery is 3.5%. The price of modern devices has been placed currently to local market price without counting tax. Calculating the arithmetic average for machinery and the total number of machines means taking the prices of all machines of the same class and calculating of all values and dividing by the number of machines.

The arithmetic mean*number of machine= value for one type of machine

Some machines are different in sizes and origin country with different specifications of and that many of the tools have been lost sticker labeled. Also, losing the serial number and, name of company, the date of manufacture and machine specifications. The age of some machines is 35 years from 1975, but many of these machines still work and some works part-time.

Recommendations and Suggestions

It has been noticed that the school administration which is the direct responsible on workshops organize the work within clearly-stated and limited goals. RMS trains the engineers and technicians in a very good way. This training is usually

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during the work, and it is a basic element in raising the skill and quality of the engineers and technicians.

There is a maintaining plan for the machines in the workshops, and this plan includes the protective maintenance. However, the budget which is annually paid is not enough to perform sufficient maintenance. Also, there are not enough modern machines to sync the development in the world of industry and technology.

In addition, the machines are not always able to produce and compete, and they do not take into consideration the safety conditions. Finally, the workers have high abilities in machines maintenance.

Modern techniques are not used in storing the spare parts, and sometimes the international standards are used in manufacturing some materials. However, RMS always provides high quality materials that have international standards. In addition, the working equipment in the workshops is provided with alarms. Furthermore, the quality assurance is done by the engineers and supervisors.

The workshops do not always have enough space for storing big spare parts. Also, they do not always provide the appropriate safety conditions for storing of the materials. However, the supervision procedures occupy a high percentage in the industrial workshops.

When it comes to the machines, the history of the machines, which includes the date of starting the machine, is registered. However, moreover, the consumed spare
Parts are not registered.

Computers are not used in the maintenance and storing processes, and a percentage of 90 % of the respondents have answered that if the military hospitals were connected with each other, the processes of maintenance and parts exchange would be much easier.

Over movement, delivering materials, improper people for the proper work has occupied a percentage of 65%-75% of the wastes and losses in the hospital. Over-waiting, storing of extra materials, purchasing materials which are incompatible with the international standards have occupied a percentage of 20%-25% of the wastes and losses in the hospital. Planning properly must take into account all losses in manufacturing in the workshop, subject to the concerns and individual differences. Also, planning must organize between the existing spaces and the huge numbers of trainees and materials to be manufactured.

It is suggested to form a committee from the maintenance individuals to search from time to time on the machines and using the preventive maintenance on the medical devices. Also, the employees will increase the attention on yearly preventive and stress on the maintenance cards that are in the workshops.

The routine, writing process, complicated procedures, reports and educational writing are focused on more than other important things. Therefore, it is suggested considering and adapting the modern technology to exchange the information to reduce the procedures as much as possible and try to reduce the present losses in workshops.

The losses which happened in the MDMW in RMS should be recorded. RMS suffers from great losses, and using of computers will reduce the procedures in the maintenance programs and management of workshops.

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