An Objective Program for the Evaluation of Medical Equipment for Updates and Maintenance

Mona Aridi, Bassam Hussein, Mohamad Hajj-Hassan, Hassan M. Khachfe
Lebanese International University
Beirut, Lebanon
{mona.aridi@gmail.com}
{bassam.hussein, mohamad.hajjhassan, hassan.khachfe}@liu.edu.lb

***Abstract* — Medical equipment contribute to the quality of healthcare services on several levels. They play a key role in the diagnosis, the treatment, and the rehabilitation of the medical impairment and diseases. However, as any operating machine, medical equipment would have a definite lifespan that expires after a period of time. Theoretically, Taylor K. specified ten years as the lifespan of medical equipment. In fact, the status of the medical equipment defines its age. This status should be addressed according to a list of criteria that evaluate the efficiency and the performance of these equipment. The purpose of this study is to develop a well-designed plan for evaluating medical equipment. According to this evaluation, we can rank the equipment that should be replaced in the descending order of urgency taking into account many criteria and sub-criteria.**

Keywords-efficiency; healthcare; lifespan; medical equipment; performance.

I. LITERATURE REVIEW

Assessment of medical equipment is increasingly becoming the concern of healthcare institutions. Many companies concentrated their studies on the evaluation of medical technology and the investigation of their accidents. In the early 1990s, the world raised the attention to the device-related activities and many regional offices were opened all over Europe, the Middle East, and Asia Pacific [1]. Moreover, the International Medical Device Regulators Forum (IMDRF) discussed the future directions in medical device regulatory harmonization [2]. Furthermore, the International Organization for Standards (ISO) defined ISO 13485 as a standard for assessing and maintaining the efficacy of medical equipment. It deals with the specifications of medical technology to meet healthcare requirements for healthier outcomes [3]. In addition, the US Food and Drug Administration (FDA) generated a Device Evaluation Intern Program (DEIP) to monitor the efficiency, safety, and degree of risk to public health of the medical equipment [4].

A. Kirisits and W. K. Redekop highlighted the economic evaluation as a critical key point that stands behind the decision making for an equipment-upgrading program [5]. The clinical investigation of medical devices in Europe focuses on outlining the risks that may threaten both the patient and the staff [6]. However, among all the calls regarding the evaluation of medical equipment, a study done by Sharareh Taghipour in 2011 assigned six main criteria in which some of them are branched intao sub-criteria [7]. Sharareh focused on the recalls and hazard alerts that may occur for medical equipment. Moreover, concerning the risks, a great deal of attention is given to the failure frequency, the possible redetect of the risk, and the failure consequences, where we investigated the safety and environment effect of the device.

On the other hand, Sharareh raised the attention to the operational and the non-operational consequences of a failure, to inspect the cost of repair. This inspection investigates the 'manpower' and the 'spare parts' costs to fix a defect. Besides, the Canadian study boosted the attention to the out of service periods and the number of patients waiting due to those failures, which is defined as the downtime of the device.

Here, a new evaluation technique, similar to the Canadian one, which will be highlighted later in the paper, is proposed but with less required data. In our model, we tried to make the investigation simple and direct so we focused on the function and the age of the medical equipment, as well as we focused on the mission criticality, the risks, and the maintenance requirements. Actually, collecting data for each criterion is very hard and requires a long questionnaire, so we designed a checklist questionnaire to gather the required data about each equipment. As a case study, we applied this model on a Lebanese public hospital and we came back with a list of equipment that should be replaced after a period of time as defined by the hospital.

In this paper, we are going to propose the methodology of the study in the "Proposed Methodology" paragraph. Then we are going to show the way to derive the weights and the intensities of the tested criteria in the "Parameters" Section. After that, we are going to present the missions to accomplish the assessment plan through the "Mission" section. In the "Evaluation and Discussion" section, we will be analyzing the obtained results and make a decision accordingly. This will be followed by "Case Study" to test

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the validity of the presented technique. Finally, we will end up with a conclusion and our further expectations through the "Conclusion".

II. PROPOSED METHODOLGY

Medical devices play a significant role in providing healthcare as they affect the patient and the care providers directly. Besides, the design of the medical equipment gives a share in the safety of the environment [8]. The excessive use of the medical equipment is directly proportional to its performance with time, which will shorten its expected lifespan. The clinical evaluation of medical technology should be based on a comprehensive analysis that covers relevant criteria and parameters to appraise the efficiency of the equipment.

This paper proposes a model to evaluate the medical equipment according to measurable criteria and quantitative parameters that identify the time after which this equipment should be replaced. To start, we are going to identify some main criteria in which some of them are branched into sub-criteria. To make our work measurable, we assigned each criterion and sub-criterion to a specific weight that defines its criticality.

Many methods can be used to appraise and weight clinical data. In our study, we take into account five main criteria in which some of them are divided into sub-criteria. Each criterion has a certain weight that specifies its weight in the study. Moreover, each criterion is limited to a certain range of choices, where every choice is assigned to certain intensity.

After defining the grades and intensities for all criteria, the model will be ready for use to assess the devices. To compute the final score, we need to calculate the total score that is the summation of the product of intensities and weights for each criterion. After that, we should calculate the Normalized Score Value that indicates the relative importance of each device in comparison with other devices, from which we generated the Transformed Score Value. The transformed score value is the value that allows us to rank the medical device according to its importance.

III. PARAMETERS

For a measurable reliable ranking for the medical devices, we should introduce some grades known as intensities and weights for each criterion and sub-criterion. The grades may encounter several classes for one criterion. For example, the maintenance requirements of a device may be high, medium, or low. The definition of each class differs from one hospital to another depending on the decision makers at each hospital. Consequently, the term 'low' for maintenance requirements differs from hospital to another.

If the criterion of a device contributes with its maximum capacity to the upper-level of this criterion, then its intensity should record a value of 1.

According to Sharareh, the intensities and the weights are obtained from a pairwise comparison matrix of qualitative grades, which is built using expert opinion [7].

The weight of each grade is obtained using Equation 1:

$$v_i = \frac{\left(\prod_{j=1}^{5} a_{ij}\right)^{\frac{1}{5}}}{\sum_{i=1}^{5}\left(\prod_{j=1}^{5} a_{ij}\right)^{\frac{1}{5}}} \quad i= 1, \ldots, 5, \quad j= 1, \ldots, 5 \quad \text{(Equation 1)}$$

The intensity of each grade is obtained using Equation 2:

$$Intensity = \frac{v_i}{\max(v_i)} \quad i= 1, \ldots, 5, \quad \text{(Equation 2)}$$

Table I. PAIRWISE COMPARISON MATRIX FOR THE GRADE OF CRITERION 'FUNCTION'.

	Life saving	Therapeutic	Diagnostic	Analytic	Misc.
Life saving	1.00	5.00	6.00	8.00	9.00
Therapeutic	0.20	1.00	1.60	1.40	1.80
Diagnostic	0.17	0.63	1.00	1.25	1.50
Analytic	0.13	0.71	0.80	1.00	1.29
Misc.	0.11	0.56	0.67	0.78	1.00

Table I shows the pairwise comparison matrix for the grades of criterion 'Function' as assigned by expert opinion. Using above table and formulas, we can calculate the intensities and the weight for the criterion 'Function'. We listed the results in Table II, using the Equations 3 and 4:

$$\text{where } a = \left(\prod_{j=1}^{5} a_{ij}\right) \quad \text{(Equation 3)}$$

$$\text{and } b = \left(\prod_{j=1}^{5} a_{ij}\right)^{\frac{1}{5}} \quad \text{(Equation 4)}$$

Table II. CALCULATING THE INTENSITIES OF THE CRITERION 'FUNCTION'.

	a	b	v_i	Intensity
Life saving	2160.00	4.64	0.62	1.00
Therapeutic	0.81	0.96	0.13	0.21
Diagnostic	0.20	0.72	0.10	0.16
Analytic	0.09	0.62	0.08	0.13
Miscellaneous	0.03	0.50	0.07	0.11
$\sum_{i=1}^{5} b = 7.45$				

In our model, we discarded the sixth criterion, which I "Recalls and Hazards" from the study as it is not available in the hospital where the study was done. We distributed 0.16, the weight of recalls and hazards, on the other criteria by adding 0.032 on each of the five criteria. For example, the weight of the criterion "Function" is 0.45. After adding 0.032 it becomes 0.482.

IV. MISSIONS

Assessment of medical equipment requires five consecutive missions where each one deals with a criterion. The core of each mission is gathering data. Before going through any of the missions, we made up an identity card for each equipment by filling up its name, its serial number, its brand, and its manufacturer. This information will not affect our study, but the aim is rather to identify each equipment to make sure that there is no overlapping in case the equipment is shared among the units and departments.

The intensities are obtained from a pairwise comparison of grades; experts construct these grades

First Mission: In the first mission, we classified the function of each medical equipment into five categories: lifesaving, therapeutic, diagnostic, analytic, and miscellaneous according to the classification developed by Fennigkoh, Smith, and Dhillion [9]. The weight of the function and the intensity of each category are shown in Table III.

Table III: THE INTENSITIES OF THE FUNCTION OF THE EQUIPMENT.

Function (0.482)				
Life saving	Therap.	Diagnostic	Analytic	Miscellaneous
1.00	0.21	0.16	0.13	0.11

Second Mission: This mission accomplishes the second criterion; mission criticality of weight (0.132) is divided into two sub-criteria: the utilization and the availability of alternative devices, as shown in Figure 1.

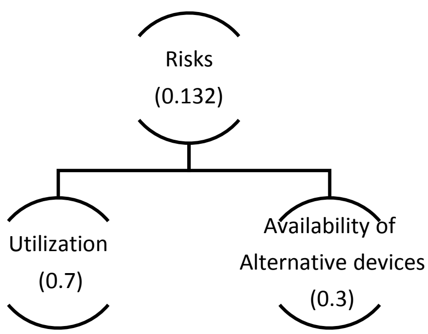

Figure 1. Hierarchy for mission criticality.

The usage of the device and its back-up devices identify the load of work on that device. Moreover, using the equipment excessively will increase the failure on the equipment [10]. In the first sub-criterion, utilization of a device is the total hours the device is used on average in a hospital (the unit can be defined as hours per day or days per week or weeks per year). In our proposed model, we considered the ‘average hours a device is used per week’ for the utilization criterion divided into three classes as shown in Table IV.

Table IV. THE WEIGHT AND INTENSITIES OF THE USAGE OF MEDICAL EQUIPMENT.

Usage hour/week (0.70)		
24≤	12≤x<24	<12
1.00	0.34	0.15

On the other hand, the availability of alternatives affects the mission criticality as it represents the number of similar or backup devices for one equipment. However, as the number of similar devices at hand becomes fewer because of lack of backup of the medical equipment the risks on that equipment will increase. Furthermore, having several similar devices with low demand may also harm the device by affecting its performance from one side and by costing the hospital regular preventive maintenance from the other side. The weight and the intensities of the availability of alternatives are shown in Table V.

Table V. THE WEIGHT AND THE INTENSITIES OF THE ALTERNATIVES.

Alternatives (0.30)		
≤1	1< x≤4	>4
1.00	0.34	0.20

Third Mission: The third mission deals with the third criterion, which is the age of the equipment. The age of the medical device is based on the actual age of a device and its predictable life span. In general, 10 years is the average life span for a medical device. The equipment are divided into five categories according to the actual age of the equipment divided by the life span as shown in Table VI. As the ratio approaches 1, the equipment is considered as old otherwise, it is considered to be new as the ratio approaches zero. The age ratio is expressed in equation 5:

$$Age\ Ratio = \frac{Actual\ Age}{Life\ Span} \qquad \text{(Equation 5)}$$

Table VI. THE WIGHT AND THE INTENSITIES OF THE AGE OF THE MEDICAL EQUIPMENT.

Age (0.092)				
>1	0.75< x≤1	0.5<x≤0.75	0.25<x≤0.5	0≤x≤0.25
1.00	0.67	0.43	0.17	0.12

Fourth Mission: The fourth mission addresses the fourth criterion, which is the risk of a device of weight (0.192). In a patient-centric environment, managing risk is the top priority that occupies a worthy space under the umbrella of the healthcare [11]. The risk of a device is the summation of all risks threatening patients. These risks can be estimated from the actual failures, which have occurred in that device, are shown in the figure below. Figure 2, shows the three sub-criteria of risks. The consequences associated to the risks of a device are assigned by the failure frequency, the detectability, and the failure consequences should be extracted or estimated from data history and device maintenance archive [12].

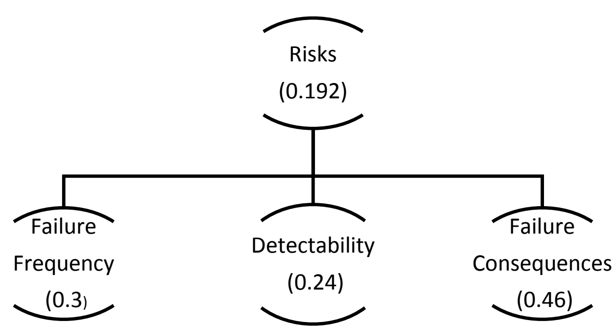

Figure 2. Hierarchy for risks on the medical equipment.

The frequency of failure tells whether the failure is occurring frequently or not. For that, we considered four levels for the frequency of failure shown in Table VII. If the failure is frequent, it means that the failure is likely to occur (several occurrences in 1 year). If the failure is occasional, it means that it probably will occur (several occurrences in 1 to 2 years). If it is uncommon, it means that it is possible to occur (one occurrence in 2 to 5 years). If it is remote, it means that it is unlikely to occur (one occurrence in 5 to 10 years).

Table VII. THE WEIGHT AND INTENSITIES OF THE FREQUENCY OF FAILURE.

Frequency of Failure (0.3)			
Frequent	Occasional	Uncommon	Remote
1.00	0.33	0.20	0.15

Failure detectability is the ability to detect a failure when it occurs. This is the most important criteria to assess harm [11]. We can detect the failure at many different levels. In our model, we used four levels of detectability. The failure maybe detected by error; that is when the equipment stops working, by inspection during the regular preventive maintenance rounds, it might be visible by naked eye or it can be detected by self-announcement, as summarized below in Table VIII:

Table VIII. THE WEIGHT AND INTENSITIES OF THE DETECTABILITY.

Detectability (0.24)			
Error	Inspection	Visible	Self-announcement
1.00	0.33	0.20	0.13

The failure consequences of weight (0.46) deal with the safety and the environment where we discuss the effect of the failure on the patient and the staff [13]. The failure of the medical equipment may harm the patient at different levels. It may cause death in extreme cases, injury in which it may disable the patient, inappropriate therapy, misdiagnosis, which makes the situation worse or the failure, which may cause a delay in the treatment. Finally, in some other situations, it may cause nothing. The intensities of those failures are summarized in Table IX.

Table IX. THE WEIGHT AND INTENSITIES OF THE FAILURE CONSEQUENCES.

Failure Consequences (0.46)				
Death	Injury	Inapp. Therapy or misdiagnosis	Delay in treatment or diagnosis	Non
1.00	0.34	0.21	0.14	0.09

The risk value can then be estimated as a function of frequency, consequence, and detectability for each failure mode. As a result, the risk of the device is the total risk of all its failure modes.

Fifth Mission: The last criterion, which is the fifth one where we studied the maintenance requirement for every medical equipment, is covered in the fifth mission. The availability of the medical equipment should be based on maintenance history and the maintenance requirements [14]. According to Fennigkoh and Smith [15], equipment that is predominantly mechanical, pneumatic, or fluidic often requires the most expensive maintenance. A device is considered to have an average maintenance requirement if it requires only performance verification and safety testing. Equipment that receives only visual inspection, a basic performance check, and safety testing is classified as having minimal maintenance requirements. We defined each of these classes as high, medium, and low with their corresponding intensities as shown in Table X.

Table X. THE WEIGHT AND INTENSITIES OF THE MAINTENANCE REQUIREMENTS.

Maintenance Requirements (0.102)		
High	Medium	Low
1.00	0.50	0.17

Identifying the main and the sub-criteria of each equipment allows us to determine their relative importance according to their goal or their upper level criterion using Saaty's eigenvector technique-a mathematical technique that assigns a total score value for each medical device under study. This technique is used in multi-criteria decision-making missions [16]. This total score is generated from the weights and the intensities of those medical devices from the matrix of criteria and sub-criteria observed [17], [18]. Figure 3, show a schematic diagram of the main, and sub criteria of the evaluation test.

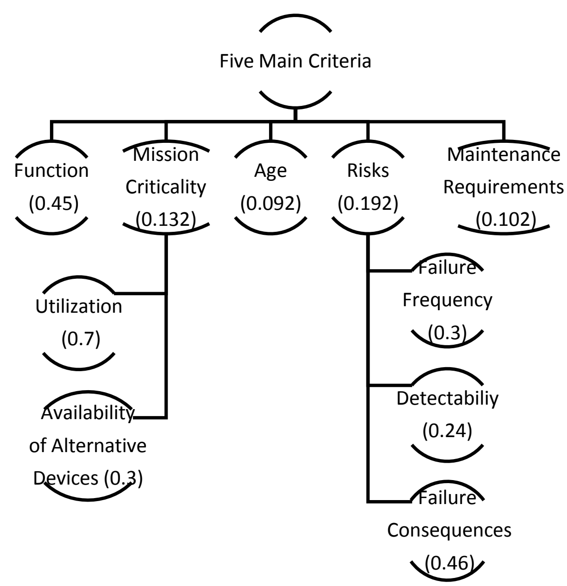

Figure 3. Hierarchy for the fve main criteria.

V. EVALUATION AND DISCUSSION

After filling the above questionnaire for each equipment, we can compute the scores using the assigned weights and intensities. The total score of each equipment is the summation of the weight × intensity for the five criteria (Equation 6).

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$$Total\ Score = \sum_{j=1}^{5} \mathrm{w_j}\, \mathrm{s_{ij}} \quad \text{(Equation 6)}$$

$$Total\ Score = w_{function} \times i_{function} + w_{age} \times i_{age} + w_{mission\ criticality} \times [w_{usage} \times i_{usage} + w_{back-up} \times i_{back-up}] + w_{risks} \times [w_{failure\ consequences} \times i_{failure\ consequences} + w_{detectability} \times i_{detectability} + w_{frequency} \times i_{frequency}] + w_{maintenance\ requirements} \times i_{maintenance\ requirements}$$

Where "w" is the weight of each criterion "j" = 1, 2 … 5 and "i" is the intensity of each class.

At this stage, we listed the total score for the equipment in descending order from the highest score to the lowest score. This rank helps us in calculating the normalized score value that indicates the relative criticality of a device compared to other devices. Therefore, the Normalized Score Value of each equipment (Equation 7):

$$NSV = \frac{\textbf{Total score of each device}}{\textbf{Maximum total score}} \quad \text{(Equation 7)}$$

The aim of this study is to prioritize the medical devices according to their criticality. To do so, we have to calculate the transformed score value from the above procedure, which can be used for prioritizing or ranking of devices. The Transformed Score Value depends on the Normalized Score Value of each device involved in the model and on the minimum and the maximum scores that could be achieved. The transformed score value plays an important role in assessing the medical equipment according to a percentage. In our proposed model, devices can have a total score between (0.1257592, 1.0) where score 1.0 is for a device, which gets the highest intensity when assessed against every single criterion and 0.1257592 is obtained when the device gets the lowest intensity from all criteria. The calculation is shown below using equation 6:

$$Minimum\ Total\ Score\ Value = (0.482 \times 0.11) + 0.132[(0.7 \times 0.15) + (0.3 \times 0.2)] + (0.092 \times 0.12) + 0.192[(0.3 \times 0.15) + (0.24 \times 0.13) + (0.46 \times 0.09) + (0.102 \times 0.17) = 0.1257592$$

However, the total scores of devices can be used as absolute measurements for classification. The ranking of the medical devices can be done according to the normalized score value, however, for a better reading we can express the results in percentage, and so the normalized score value can then be mapped to (0, 100%) Transformed Score Value using the following equation:

$$TSV = \frac{\textbf{Score value} - \textbf{Minimum}}{\textbf{Maximum} - \textbf{Minimum}} \times \mathbf{100} \quad \text{(Equation 8)}$$

$$= \frac{\textbf{Score value} - \mathbf{0.1257592}}{\mathbf{1.00} - \mathbf{0.1257592}} \times \mathbf{100}$$

$$= \frac{\textbf{Score value} - \mathbf{0.1257592}}{\mathbf{0.87311}} \times \mathbf{100}$$

The whole process is summarized in Table XI:

Table XI. THE TRANSFORMED SCORE VALUE.

Equip.	Total Score	NSV	TSV
↓	Descending order	$\frac{(Total\ score\ of\ each\ device)}{max.\ Total\ score}$	$\frac{Score\ value - minimum}{maximum - minimum} \times 100$
			$\frac{Score\ value - 0.1257592}{1.00 - 0.1257592} \times 100$
			$\frac{Score\ value - 0.1257592}{0.87311} \times 100$

The obtained list of medical equipment can be classified into many categories according to the prioritizing plan of the hospital, which is related to the budget assigned by the decision makers. In our study, the criticality of a device is classified into three categories in which a transformed score value should belong. The first category is for those, which should be replaced urgently. The second one for those, which should be replaced after a year and a half (their replacement can be limited to a deadline defined by the hospital according to their budget). The third one is for those, which are still functioning normally and can work for several years ahead. Using the transformed score value we can sort the medical equipment according to their urgency using Table XII.

Table XII. THE CRITICALITY OF A DEVICE FROM THE TRANSFORMED SCORE VALUE.

Criticality class	Transformed Score Value	Maintenance Strategy
High	65% <TSV≤ 100%	To be changed urgently
Medium	50% < TSV ≤ 65%	To be changed after a year and a half
Low	0% ≤ TSV ≤ 50%	To be changed after three years

Using the above study, we can easily rank the equipment of a hospital in the order of their urgent need for replacement. If the equipment's score is between 65% and 100%, it means that the equipment should be replaced immediately. If its score ranges between 50% and 65%, then the equipment should be replaced after a while. Finally, if its score is less than 50%, this means that the replacement of the equipment does not need to happen in the near future. Keep in mind that we can consider other intervals to sort the tested devices according to the hospital's financial contribution.

VI. CASE STUDY

In this section, we are going to apply the assessment model on the medical equipment found in some units of a Lebanese hospital in order to evaluate them for an updating program.

To do this, we have chosen the Dialysis and the critical care units as a sample study. In these critical units, we have the Intensive Care Unit (ICU), which is dedicated to treat patients, who are seriously ill. Besides, we have the Coronary Care Unit (CCU), where patients with a pacemaker, intra-aortic balloon pump, or with cardiac telemetry are treated. Moreover, there is the Cardiac Surgical Unit (CSU), where patients having open-heart, lung, or vascular surgery are recovered. In addition, there is the Neonatal Intensive Care Unit (NICU) is the unit that monitors the neonates, who are facing newborn problems. Finally, the Pediatric Intensive Care Unit (PICU) is the intensive care specialized for the pediatrics.

In these units, we dealt only with the medical equipment that is in direct contact with the patient and that might affect the patients' safety. The equipment that are related to the ward medical equipment, housekeeping equipment, mortuary equipment, general furniture and accessories, are considered as not urgent at all so they are kept away from the study with "to be replaced after a determined period of time" as an general status. We gathered the required data for 324 equipment distributed over 35 different items and we came back with the results listed in Table XIII. As you can notice, from the obtained results, the same item may record different grades when used in different units. For example, the ECG in the ICU records a grade of 57.35 whereas the ECG in the NICU recorded a grade of 42.88. These two different grades for the same item reflect the different mode of use and different urgency of that equipment at its unit.

Table XIII. SCORES AND GRADES FOR EACH ITEM.

Nb.	Name	Normalized Score	Transformed Score (%)
1	Defibrillator	1	100
2	Blood Gas system	0.84776143	82.563644
3	Pulse Oximeters	0.83167396	80.721096
4	Infusion pump (CCU)	0.80675075	77.866563
5	Monitor (ICU)	0.76745621	73.366037
6	Oximeters	0.76154527	72.689039
7	Syringe pump (ICU)	0.75121329	71.505686
8	Dialysis	0.74112659	70.350424
9	Monitor (CCU)	0.69471468	65.034724
10	Monitor (Endoscopy)	0.68912238	64.394221
11	Syringe pump (PICU)	0.68817904	64.286177
12	Refrigerator Pharmacy)	0.68541098	63.969142
13	Monitor (Dialysis)	0.68198543	63.576804
14	Incubator(PICU)	0.67304633	62.552981
15	Refrigerator (NICU)	0.66928522	62.122209
16	Refrigerator (PICU)	0.66928522	62.122209
17	Incubator (mobile)	0.66080627	61.151088
18	Syringe pump (floors)	0.65123852	60.055265
19	Incubator (Therapeutic)	0.64902559	59.801811
20	ECG (ICU)	0.62764624	57.353167
21	Fetal Monitor	0.62328606	56.853783
22	x-ray (ICU)	0.60806278	55.110213
23	Ultrasound Unit	0.59212049	53.284293
24	Reanimation & warming table	0.58451048	52.412695
25	ECG (CCU)	0.57761153	51.622536
26	ECG (Dialysis)	0.56972919	50.719747
27	Infusion Pump (NICU)	0.56173091	49.80368
28	Infusion Pump (floors)	0.54855002	48.294032
29	Lactina Electric pulse	0.52413795	45.498041
30	CPR	0.52413795	45.498041
31	ECG (NICU)	0.50133159	42.885958
32	Fetal Doppler	0.48090312	40.546222
33	Incubator (Delivery Unit)	0.43585151	35.386322
34	Otoscope	0.39837394	31.093899
35	Bair Hugger	0.24364574	13.372397

At this stage, we are able to make our decision. According to the hospital's budget, we can set three consecutive categories; each bounded within an interval of grades that matches the updating strategic plan of the hospital. In our case study, we assigned the three categories based on a strategic updating plan set by the hospital. The decision makers at that hospital were planning to spend a certain budget after the results of the study, and another amount after a year and a half and finally another amount after three years. Consequently, we set the coming three missions, as seen in Table XIV; the equipment with grades between 65% and 100% should be replaced directly. Those with grades between 50% and 65% can be replaced after a year and a half, and finally, those with grades below than 50% can be replaced after three years from the first updating plan.

Table XIV. THE CRITICALITY OF A DEVICE FROM THE TRANSFORMED SCORE VALUE - CASE STUDY

Criticality class	Transformed Score Value	Maintenance Strategy
High	65% <TSV≤ 100%	To be changed urgently
Medium	50% < TSV ≤ 65%	To be changed after a year and a half
Low	0% ≤ TSV ≤ 50%	To be changed after three years

Based on the above three ranges of grades, we can summarize the three groups of medical equipment as shown in Table XV:

Table XV. RESULTS FOR THE UPDATING PLAN.

To be changed urgently	To be changed after a year and a half	To be changed after three years
High 70% <TSV≤ 100%	**Medium** 50% < TSV ≤ 70%	**Low** 0% ≤ TSV ≤ 50%
Defibrillator	Monitor (Endoscopy)	Infusion Pump (NICU)
Blood Gas System	Syringe pump (PICU)	Infusion Pump (floors)
Pulse Oximeter	Refrigerator (Pharmacy)	Lactina Electric pulse
Infusion pump	Monitor (Dialysis)	CPR
Monitor (ICU)	Incubator(PICU)	ECG (NICU)
Oximeters	Refrigerator (NICU)	Fetal Doppler
Syringe pump (ICU)	Refrigerator (PICU)	Incubator (Delivery Unit)
Dialysis	Incubator (mobile)	Otoscope
Monitor (CCU)	Syringe pump (floors)	Bair Hugger
	Incubator (Therapeutic)	
	ECG (ICU)	
	Fetal Monitor	
	x-ray (ICU)	
	Ultrasound Unit	
	Reanimation & warming table	
	ECG (CCU)	
	ECG (Dialysis)	

To make sure that the obtained results are correct and the devices to be changed meet the hospital's requirements, we designed a questionnaire that questions the physicians the technicians, and the doctors. In the questionnaire, we asked for the equipment that should be replaced directly and we came back with a list that matched the above list obtained by the scientific study.

One can do some modifications on the result, especially for the equipment on the boundaries. For example, the endoscopy monitor recorded 64.39% so it should belong to the second category. However, if the doctors and the physicians, who work on the endoscopy monitor, recommended an urgent replacement for this monitor, we can move it to the first category and add it to the equipment to be replaced directly. This will not be considered an error since the endoscopy monitor is on the boundary so it may belong to both categories.

Finally, once the hospital has the results, it should launch the procurement process for the first category list.

VII. CONCLUSION

Medical equipment is a critical interface between the patient and the diagnosis, the treatment, or the rehabilitation process. It provides an opportunity for a better medical service. Consequently, medical devices are expected to operate in the required way providing the ultimate results of accuracy, safety, and reliability for an efficient and healthy contribution. As such, this study provides a new model for assessing the life of medical equipment based on its actual usage and not only speculated based on its suppositional life span. This method would result in a more accurate scheme that would most probably extend the life and usage of the equipment thus resulting in substantial savings to the healthcare institution from one side and would serve as an assessment tool based on a multi criteria decision-making approach from the other side.

Using such a model of evaluation, we can drag the wheel of change in the assessment of medical equipment to overreach several sectors in the world of machinery. Moreover, adapting an automated management system to monitor the evaluation of the medical equipment will be revolutionary move towards safety and efficiency.

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