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Determining the Priority of Medical Equipment Maintenance with Analytical Hierarchy Process in Jordan

(Priority of Medical Equipment Maintenance by AHP)

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Abstract:
Medical device maintenance and management refers to the processes and activities involved in ensuring the proper functioning, safety, and longevity of medical equipment throughout its life cycle. It includes various tasks aimed at maintaining the performance, reliability, and regulatory compliance of medical devices used in healthcare settings. So in this project the Analytic Hierarchy Process has been applied, and this includes making questionnaires, setting priorities, and determining the devices that want to make a comparison between them, and this method helps engineers to make decisions related to maintenance quickly and easily without making mistakes after making the tables extracting comparisons between them, and reading the report accurately, the hardware engineer will be able to carry out periodic maintenance of the medical devices to prevent breakdowns. This includes following existing maintenance schedules without hesitation in making a decision.

Keywords: MEM (Medical Equipment Maintenance), AHP (Analytical Hierarchy Process), MDMM (Medical device maintenance and management)

Introduction:

A modern average- to large-sized hospital will contain somewhere between 5,000 and 10,000 different types of medical devices. Hospitals and healthcare facilities must make sure that their vital medical equipment is secure, precise, dependable, and performing at the necessary level. In order to accomplish these goals, hospitals must create and enforce a Medical Equipment Management Program (MEMP) that outlines the risk management of medical equipment sure that their vital medical equipment is secure, precise, dependable, and performing at the necessary level. In order to accomplish these goals, A vital component of such a program is inspection and preventive maintenance, which needs to be regularly examined and updated in order to keep up with the rate of modern medical equipment's technological advancement and the rising demands of healthcare organizations.

After properly comprehending, putting into practice, and leading maintenance excellence in healthcare organizations, decisions on maintenance can be made that are both economical and efficient. To achieve an ideal outcome, maintenance excellence balances performance, risk, resource inputs, and cost. (Campbell and Jardine, 2001).

The majority of hospitals and healthcare organizations do not profit from maintenance excellence as much as other industries do, despite the fact that methods and procedures for maintenance have greatly improved over the past 20 years. Preventive maintenance that is both unnecessary and excessive can be both ineffective and costly. Unnecessary preventive maintenance takes up time, which deprives an organization of a small portion of one of its most precious resources. (Keil, 2008).

Hospitals in the US have begun implementing their maintenance programs to allocate their maintenance resources where they are most required since 2004, when Joint Commission on Accreditation of Healthcare Organizations (JCAHO) established standard EC.6.10 (JACAHO, 2004). According to this regulation, hospitals are not required to arrange medical equipment inspections or maintenance if the equipment is operating safely and reliably. (Wang et al., 2006). However, in Canada, the majority, if not all, healthcare organizations incorporate all of their medical equipment into their maintenance program and only adhere to the manufacturers' advice for preventative maintenance. Current maintenance techniques used in hospitals and healthcare organizations struggle to pinpoint specific risks and implement the best risk-reduction measures. (Rice, 2007).

Medical devices are essential elements of contemporary healthcare services utilized for patient diagnosis, treatment, and monitoring. To improve the capacities of healthcare diagnostic and treatment services, they are gradually being deployed. On the other hand, most underdeveloped nations still have little capacity for managing and maintaining medical equipment (World Health Organization, 1998). To handle the issues posed by the ever-increasing number and usage of medical devices, it is necessary to have effective management strategies and practical procedures.

Methodology:

In this chapter, will do begin to plan and analyze appropriately for leveraging the analytical hierarchy process, which, as explained earlier is intended to be the decision-making method used to set priorities and make complex decisions. What do Break down complex decisions into a hierarchy of criteria, subcriteria, and alternatives. Each item is then compared with every other item in pairwise comparisons based on their relative importance or preference. Each element is then assigned a numerical value based on the comparison allowing the priority or weight to be calculated for each element. These weights can be used to rank and prioritize items in order of importance which helps guide decision-making.

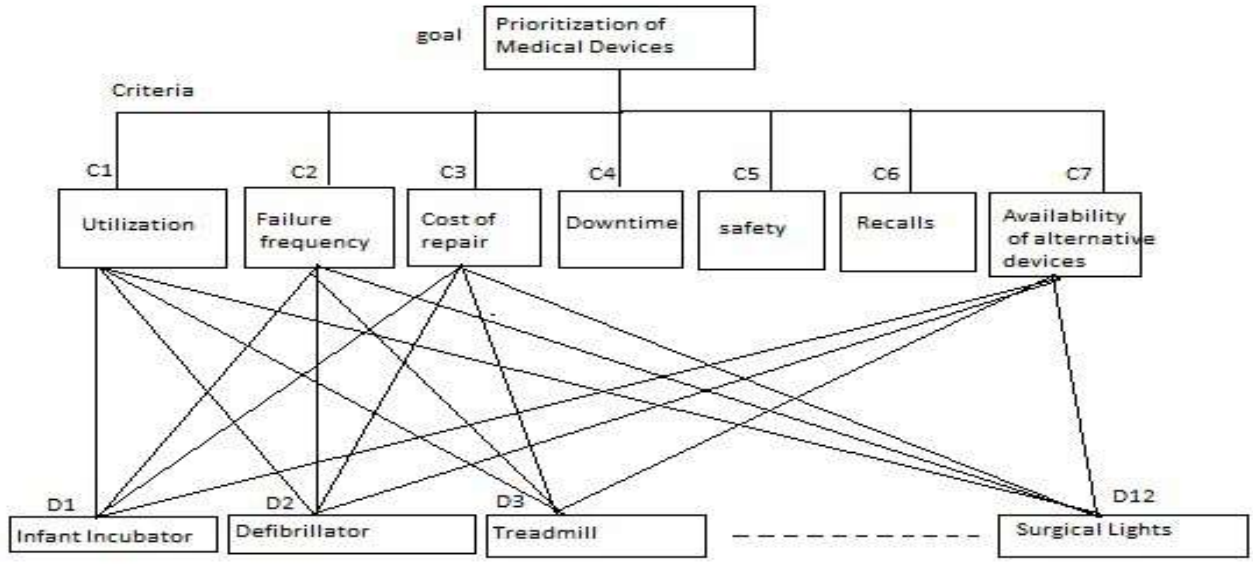

Figure 1: Decision Analytic Hierarchy Process (AHP) for Medical device maintenance

Proposed Analytic Hierarchy Process (AHP) Method for Medical device maintenance

The original AHP makes use of ratio scales. Priorities are determined by converting verbal statements (comparisons) into integers ranging from 1 to 9. There is no theoretical reason to be limited to these numbers and verbal gradations so this "fundamental AHP scale" has been discussed.

Devices:

Have 7 criteria, and one questionnaire was presented showing that the seven criteria will be worked out in this manner

The devices that the questionnaire is interested in are: Infant Incubator , Defibrillator, Treadmill, CT Scanner, Infusion Pump, ECG , X-Ray, Ultrasound Machine, Centrifuge, Blood Pressure Modules, Sterilizer , and Surgical Lights

Criteria:
Utilization, Failure frequency, Cost of repair, Downtime, Safety, Recalls, and Availability of alternative devices.
This is one table out of 7 tables that were made in the same way and format, and will explain how it was done later

Weight	Definition
1	Both elements are equally important
3	One element is a little more important than the other elements
5	One element is more important than the other elements
7	One element is clearly more important than other elements
9	One element is absolutely important than the other elements

Pairwise comparison of different medical devices with respect to criterion: Utilization
Utilization

		Extremely preferred		Strongly preferred				Equally preferred				Strongly preferred				Extremely preferred		
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	**Criteria**
1	Infant Incubator							√											Defibrillator
2	Infant Incubator			√															Treadmill
3	Infant Incubator											√							CT Scanner
4	Infant Incubator									√									Infusion Pump
5	Infant Incubator									√									ECG
6	Infant Incubator											√							X-Ray
7	Infant Incubator											√							Ultrasound Machine
8	Infant Incubator			√															Centrifuge
9	Infant Incubator	√																	Blood Pressure Modules
10	Infant Incubator									√									Sterilizer
11	Infant Incubator					√													Surgical Lights
12	Defibrillator	√																	Treadmill
13	Defibrillator							√											CT Scanner
14	Defibrillator	√																	Infusion Pump
15	Defibrillator					√													ECG
16	Defibrillator							√											X-Ray
17	Defibrillator							√											Ultrasound Machine
18	Defibrillator	√																	Centrifuge
19	Defibrillator	√																	Blood Pressure

																	Modules
20	Defibrillator							√									Sterilizer
21	Defibrillator					√											Surgical Lights
22	Treadmill															√	CT Scanner
23	Treadmill															√	Infusion Pump
24	Treadmill															√	ECG
25	Treadmill															√	X-Ray
26	Treadmill															√	Ultrasound Machine
27	Treadmill															√	Centrifuge
28	Treadmill													√			Blood Pressure Modules
29	Treadmill															√	Sterilizer
30	Treadmill															√	Surgical Lights
31	CT Scanner							√									Infusion Pump
32	CT Scanner					√											ECG
33	CT Scanner					√											X-Ray
34	CT Scanner					√											Ultrasound Machine
35	CT Scanner	√															Centrifuge
36	CT Scanner	√															Blood Pressure Modules
37	CT Scanner			√													Sterilizer
38	CT Scanner			√													Surgical Lights
39	Infusion Pump								√								ECG
40	Infusion Pump												√				X-Ray
41	Infusion Pump												√				Ultrasound Machine
42	Infusion Pump					√											Centrifuge
43	Infusion Pump			√													Blood Pressure Modules
44	Infusion Pump												√				Sterilizer
45	Infusion Pump												√				Surgical Lights
46	ECG										√						X-Ray
47	ECG										√						Ultrasound Machine
48	ECG			√													Centrifuge
49	ECG	√															Blood Pressure Modules
50	ECG										√						Sterilizer
51	ECG					√											Surgical Lights
52	X-Ray							√									Ultrasound Machine
53	X-Ray	√															Centrifuge
54	X-Ray	√															Blood Pressure

																	Modules
55	X-Ray						√										Sterilizer
56	X-Ray			√													Surgical Lights
57	Ultrasound Machine	√															Centrifuge
58	Ultrasound Machine	√															Blood Pressure Modules
59	Ultrasound Machine						√										Sterilizer
60	Ultrasound Machine			√													Surgical Lights
61	Centrifuge								√								Blood Pressure Modules
62	Centrifuge											√					Sterilizer
63	Centrifuge													√			Surgical Lights
64	Blood Pressure Modules															√	Sterilizer
65	Blood Pressure Modules															√	Surgical Lights
66	Sterilizer			√													Surgical Lights

Here explain how the differentiation table is and mention in detail what has been done

Pairwise comparison of different medical devices with respect to criterion: Utilization

Utilization	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pum	ECG	X-Ray	Ultrasound M	Centrifuge	Blood Pressu	Sterilizer	Surgical Lights	Priorites
Infant Incubator	1.000	3.000	7.000	0.333	1.000	1.000	0.333	0.333	7.000	9.000	1.000	5.000	0.099
Defibrillator	0.333	1.000	9.000	3.000	9.000	5.000	3.000	3.000	9.000	9.000	3.000	5.000	0.189
Treadmill	0.143	0.111	1.000	0.111	0.111	0.111	0.111	0.111	0.111	0.143	0.111	0.111	0.008
CT Scanner	3.000	0.333	9.000	1.000	3.000	5.000	5.000	5.000	9.000	9.000	7.000	7.000	0.202
Infusion Pump	1.000	0.111	9.000	0.333	1.000	1.000	0.200	0.200	5.000	7.000	0.200	0.200	0.043
ECG	1.000	0.200	9.000	0.200	1.000	1.000	0.333	0.333	7.000	9.000	0.333	5.000	0.058
X-Ray	3.000	0.333	9.000	0.200	5.000	3.000	1.000	3.000	9.000	9.000	3.000	7.000	0.128
Ultrasound Machine	3.000	0.333	9.000	0.200	5.000	3.000	0.333	1.000	9.000	9.000	3.000	7.000	0.111
Centrifuge	0.143	0.111	9.000	0.111	0.200	0.143	0.111	0.111	1.000	1.000	0.200	0.143	0.018
Blood Pressure Module	0.111	0.111	7.000	0.111	0.143	0.111	0.111	0.111	1.000	1.000	0.111	0.111	0.015
Sterilizer	1.000	0.333	9.000	0.143	5.000	3.000	0.333	0.333	5.000	9.000	1.000	7.000	0.080
Surgical Lights	0.200	0.200	9.000	0.143	5.000	0.200	0.143	0.143	7.000	9.000	0.143	1.000	0.048
													1.000

Figure 2: device comparisons in utilization just

have produced diagonal cells in orange that contain the number 1 which is when the device meets itself. As for the numbers in the table and device comparisons it depends on the previous table and will explain exactly what has been done

In the gudgment scale method, the data was emptied from the previous table. When the device meets itself, the number 1 is placed, and it forms diagonally down to Proiorites which is the sum of the numbers in the column when filling in the data. only empty what is above the diagonal line and what is below it is through the Excel program It does the calculation to reflect the value of the numbers entered at the top that is get the numbers entered at the top through the questionnaire at the top and below the diagonal line that contains the number 1 is a reflection.

Using this equation calculate the average of the device priorities

$$\frac{device\ 1 + device\ 2 + device\ 3 + \cdots .}{Numbers\ of\ devices}$$

Calculating:

Then move to the calculating table take the numbers from the main tables, then add the numbers in each column through an equation entered in Excel then divide each cell from the same column by the sum and get the number in the same place as the cell, then collect each row and divide it by 12 So get the average and thus produce our pririte numbers At the end of the pririte have the sum number 1

And apply that to all of our tables

Table 1: Pairwise comparison of different medical devices with respect to criterion: Utilizatin

Utilization	Infant Incu	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Press	Steriliter	Surgical Lights
Infant Incubator	1.000	3.000	7.000	0.333	1.000	1.000	0.333	0.333	7.000	9.000	1.000	5.000
Defibrillator	0.333	1.000	9.000	3.000	9.000	5.000	3.000	3.000	9.000	9.000	3.000	5.000
Treadmill	0.143	0.111	1.000	0.111	0.111	0.111	0.111	0.111	0.111	0.143	0.111	0.111
CT Scanner	3.000	0.333	9.000	1.000	3.000	5.000	5.000	5.000	9.000	9.000	7.000	7.000
Infusion Pump	1.000	0.111	9.000	0.333	1.000	1.000	0.200	0.200	5.000	7.000	0.200	0.200
ECG	1.000	0.200	9.000	0.200	1.000	1.000	0.333	0.333	7.000	9.000	0.333	5.000
X-Ray	3.000	0.333	9.000	0.200	5.000	3.000	1.000	3.000	9.000	9.000	3.000	7.000
Ultrasound Machine	3.000	0.333	9.000	0.200	5.000	3.000	0.333	1.000	9.000	9.000	3.000	7.000
Centrifuge	0.143	0.111	9.000	0.111	0.200	0.143	0.111	0.111	1.000	1.000	0.200	0.143
Blood Pressure Modules	0.111	0.111	7.000	0.111	0.143	0.111	0.111	0.111	1.000	1.000	0.111	0.111
Steriliter	1.000	0.333	9.000	0.143	5.000	3.000	0.333	0.333	5.000	9.000	1.000	7.000
Surgical Lights	0.200	0.200	9.000	0.143	5.000	0.200	0.143	0.143	7.000	9.000	0.143	1.000
sum	13.930	6.178	96.000	5.886	35.454	22.565	11.010	13.676	86.111	81.143	19.098	44.565

Utilization	Infant Incu	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Press	Steriliter	Surgical Lights	sum	prirites
Infant Incubator	0.072	0.486	0.073	0.057	0.028	0.044	0.030	0.024	0.101	0.111	0.052	0.112	1.191	0.09924
Defibrillator	0.024	0.162	0.094	0.510	0.254	0.222	0.272	0.219	0.130	0.111	0.157	0.112	2.267	0.18891
Treadmill	0.010	0.018	0.010	0.019	0.003	0.005	0.010	0.008	0.002	0.002	0.006	0.002	0.095	0.00796
CT Scanner	0.215	0.054	0.094	0.170	0.085	0.222	0.454	0.366	0.130	0.111	0.367	0.157	2.424	0.20197
Infusion Pump	0.072	0.018	0.094	0.057	0.028	0.044	0.018	0.015	0.072	0.086	0.010	0.004	0.519	0.04325
ECG	0.072	0.032	0.094	0.034	0.028	0.044	0.030	0.024	0.101	0.111	0.017	0.112	0.701	0.05841
X-Ray	0.215	0.054	0.094	0.034	0.141	0.133	0.091	0.219	0.130	0.111	0.157	0.157	1.537	0.12804
Ultrasound Machine	0.215	0.054	0.094	0.034	0.141	0.133	0.030	0.073	0.130	0.111	0.157	0.157	1.330	0.11081
Centrifuge	0.010	0.018	0.094	0.019	0.006	0.006	0.010	0.008	0.014	0.012	0.010	0.003	0.212	0.01763
Blood Pressure Modules	0.008	0.018	0.073	0.019	0.004	0.005	0.010	0.008	0.014	0.012	0.006	0.002	0.180	0.015
Steriliter	0.072	0.054	0.094	0.024	0.141	0.133	0.030	0.024	0.072	0.111	0.052	0.157	0.965	0.08042
Surgical Lights	0.014	0.032	0.094	0.024	0.141	0.009	0.013	0.010	0.101	0.111	0.007	0.022	0.580	0.04835
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Table 2: Pairwise comparison of different medical devices with respect to criterion:failure frequency

Failure frequency	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Ligh	Priorites
Infant Incubator	1.000	7.000	0.333	5.000	0.143	1.000	5.000	5.000	3.000	0.143	0.200	7.000	0.583
Defibrillator	0.143	1.000	0.200	0.333	0.111	0.143	0.200	0.200	1.000	0.333	0.111	1.000	0.083
Treadmill	3.000	5.000	1.000	0.143	0.111	0.143	0.200	0.200	1.000	0.333	0.111	1.000	0.083
CT Scanner	0.200	3.000	7.000	1.000	0.111	0.143	0.200	3.000	0.333	0.111	0.143	0.200	0.017
Infusion Pump	7.000	9.000	9.000	9.000	1.000	0.143	9.000	9.000	9.000	7.000	7.000	9.000	0.750
ECG	1.000	7.000	7.000	7.000	7.000	1.000	9.000	9.000	7.000	1.000	0.200	0.333	0.028
X-Ray	0.200	5.000	5.000	5.000	0.111	0.111	1.000	1.000	0.333	0.111	0.111	5.000	0.417
Ultrasound Machine	0.200	5.000	5.000	0.333	0.111	0.111	1.000	1.000	0.200	0.111	0.111	0.200	0.017
Centrifuge	0.333	1.000	1.000	3.000	0.111	0.143	3.000	5.000	1.000	0.143	0.111	5.000	0.417
Blood Pressure Modules	7.000	3.000	3.000	9.000	0.143	1.000	9.000	9.000	7.000	1.000	0.200	9.000	0.750
Sterilizer	5.000	9.000	9.000	7.000	0.143	5.000	9.000	9.000	9.000	5.000	1.000	9.000	0.750
Surgical Lights	0.143	1.000	1.000	5.000	0.111	3.000	0.200	5.000	0.200	0.111	0.111	1.000	0.083
sum	25.219	56.000	48.533	51.810	9.206	11.937	46.800	56.400	39.067	15.387	9.410	47.733	

Failure frequency	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Ligh	sum	priorites
Infant Incubator	0.040	0.125	0.007	0.097	0.016	0.084	0.107	0.089	0.077	0.009	0.021	0.147	0.817	0.068
Defibrillator	0.006	0.018	0.004	0.006	0.012	0.012	0.004	0.004	0.026	0.022	0.012	0.021	0.146	0.012
Treadmill	0.119	0.089	0.021	0.003	0.012	0.012	0.004	0.004	0.026	0.022	0.012	0.021	0.343	0.029
CT Scanner	0.008	0.054	0.144	0.019	0.012	0.012	0.004	0.053	0.009	0.007	0.015	0.004	0.342	0.028
Infusion Pump	0.278	0.161	0.185	0.174	0.109	0.012	0.192	0.160	0.230	0.455	0.744	0.189	2.887	0.241
ECG	0.040	0.125	0.144	0.135	0.760	0.084	0.192	0.160	0.179	0.065	0.021	0.007	1.912	0.159
X-Ray	0.008	0.089	0.103	0.097	0.012	0.009	0.021	0.018	0.009	0.007	0.012	0.105	0.490	0.041
Ultrasound Machine	0.008	0.089	0.103	0.006	0.012	0.009	0.021	0.018	0.005	0.007	0.012	0.004	0.295	0.025
Centrifuge	0.013	0.018	0.021	0.058	0.012	0.012	0.064	0.089	0.026	0.009	0.012	0.105	0.438	0.036
Blood Pressure Modules	0.278	0.054	0.062	0.174	0.016	0.084	0.192	0.160	0.179	0.065	0.021	0.189	1.472	0.123
Sterilizer	0.198	0.161	0.185	0.135	0.016	0.419	0.192	0.160	0.230	0.325	0.106	0.189	2.316	0.193
Surgical Lights	0.006	0.018	0.021	0.097	0.012	0.251	0.004	0.089	0.005	0.007	0.012	0.021	0.542	0.045
														1

Table 3: Pairwise comparison of different medical devices with respect to criterion:cost of repair

Cost of repair	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pres	Sterilizer	Surgical Lights
Infant Incubator	1.000	7.000	5.000	0.111	7.000	1.000	0.111	0.111	5.000	9.000	0.111	1.000
Defibrillator	0.143	1.000	0.143	0.111	7.000	1.000	0.111	0.111	0.143	7.000	0.111	1.000
Treadmill	0.200	7.000	1.000	0.111	3.000	0.333	0.111	0.111	3.000	9.000	0.111	0.143
CT Scanner	9.000	9.000	9.000	1.000	9.000	9.000	3.000	3.000	9.000	9.000	3.000	7.000
Infusion Pump	0.143	0.143	0.333	0.111	1.000	3.000	0.111	0.111	1.000	0.143	0.111	0.111
ECG	1.000	1.000	3.000	0.111	0.333	1.000	0.111	0.111	5.000	9.000	0.111	1.000
X-Ray	9.000	9.000	9.000	0.333	9.000	9.000	1.000	3.000	9.000	9.000	3.000	9.000
Ultrasound Machine	9.000	9.000	9.000	0.333	9.000	9.000	0.333	1.000	9.000	9.000	3.000	7.000
Centrifuge	0.200	7.000	0.333	0.111	1.000	0.200	0.111	0.111	1.000	0.200	0.111	0.143
Blood Pressure Modules	0.111	0.143	0.111	0.111	7.000	0.111	0.111	0.111	5.000	1.000	0.111	0.111
Sterilizer	9.000	9.000	9.000	0.333	9.000	9.000	0.333	0.333	9.000	9.000	1.000	7.000
Surgical Lights	1.000	1.000	7.000	0.143	9.000	1.000	0.111	0.143	7.000	9.000	0.143	1.000
sum	39.797	60.286	52.921	2.921	71.333	43.644	5.556	8.254	63.143	80.343	10.921	34.508

Cost of repair	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pres	Sterilizer	Surgical Ligh	sum	priorites
Infant Incubator	0.025	0.116	0.094	0.038	0.098	0.023	0.020	0.013	0.079	0.112	0.010	0.029	0.659	0.055
Defibrillator	0.004	0.017	0.003	0.038	0.098	0.023	0.020	0.013	0.002	0.087	0.010	0.029	0.344	0.029
Treadmill	0.005	0.116	0.019	0.038	0.042	0.008	0.020	0.013	0.048	0.112	0.010	0.004	0.435	0.036
CT Scanner	0.226	0.149	0.170	0.342	0.126	0.206	0.540	0.363	0.143	0.112	0.275	0.203	2.856	0.238
Infusion Pump	0.004	0.002	0.006	0.038	0.014	0.069	0.020	0.013	0.016	0.002	0.010	0.003	0.198	0.016
ECG	0.025	0.017	0.057	0.038	0.005	0.023	0.020	0.013	0.079	0.112	0.010	0.029	0.428	0.036
X-Ray	0.226	0.149	0.170	0.114	0.126	0.206	0.180	0.363	0.143	0.112	0.275	0.261	2.326	0.194
Ultrasound Machine	0.226	0.149	0.170	0.114	0.126	0.206	0.060	0.121	0.143	0.112	0.275	0.203	1.905	0.159
Centrifuge	0.005	0.116	0.006	0.038	0.014	0.005	0.020	0.013	0.016	0.002	0.010	0.004	0.250	0.021
Blood Pressure Modules	0.003	0.002	0.002	0.038	0.098	0.003	0.020	0.013	0.079	0.012	0.010	0.003	0.284	0.024
Sterilizer	0.226	0.149	0.170	0.114	0.126	0.206	0.060	0.040	0.143	0.112	0.092	0.203	1.641	0.137
Surgical Lights	0.025	0.017	0.132	0.049	0.126	0.023	0.020	0.017	0.111	0.112	0.013	0.029	0.674	0.056
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Table 4: Pairwise comparison of different medical devices with respect to criterion:Downtime

Downtime	Infant Inc	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Lights
Infant Incubator	1.000	5.000	7.000	0.111	5.000	1.000	0.111	0.111	5.000	9.000	0.111	0.200
Defibrillator	0.200	1.000	3.000	0.111	5.000	5.000	0.111	0.111	1.000	3.000	0.111	0.200
Treadmill	0.143	0.333	1.000	0.111	3.000	1.000	0.111	0.111	3.000	7.000	0.111	0.143
CT Scanner	9.000	9.000	9.000	1.000	9.000	9.000	3.000	3.000	9.000	9.000	5.000	7.000
Infusion Pump	0.200	0.200	0.333	0.111	1.000	0.200	0.111	0.111	0.200	7.000	0.111	0.143
ECG	1.000	0.200	1.000	0.111	5.000	1.000	0.111	0.111	0.333	9.000	0.111	0.143
X-Ray	9.000	9.000	9.000	0.333	9.000	9.000	1.000	0.111	9.000	9.000	3.000	7.000
Ultrasound Machine	9.000	9.000	9.000	0.333	9.000	9.000	9.000	1.000	9.000	9.000	3.000	5.000
Centrifuge	0.200	1.000	0.333	0.111	5.000	3.000	0.111	0.111	1.000	7.000	0.143	0.200
Blood Pressure Modules	0.111	0.333	0.143	0.111	0.143	0.111	0.111	0.111	0.143	1.000	0.111	0.111
Sterilizer	9.000	9.000	9.000	0.200	9.000	9.000	0.333	0.333	7.000	9.000	1.000	7.000
Surgical Lights	5.000	5.000	7.000	0.143	7.000	7.000	0.143	0.200	5.000	9.000	0.143	1.000
sum	43.854	49.067	55.810	2.787	67.143	54.311	14.254	5.422	49.676	88.000	12.952	28.140

Downtime	Infant Inc	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Ligh	sum	prirites
Infant Incubator	0.023	0.102	0.125	0.040	0.074	0.018	0.008	0.020	0.101	0.102	0.009	0.007	0.630	0.052
Defibrillator	0.005	0.020	0.054	0.040	0.074	0.092	0.008	0.020	0.020	0.034	0.009	0.007	0.383	0.032
Treadmill	0.003	0.007	0.018	0.040	0.045	0.018	0.008	0.020	0.060	0.080	0.009	0.005	0.313	0.026
CT Scanner	0.205	0.183	0.161	0.359	0.134	0.166	0.210	0.553	0.181	0.102	0.386	0.249	2.890	0.241
Infusion Pump	0.005	0.004	0.006	0.040	0.015	0.004	0.008	0.020	0.004	0.080	0.009	0.005	0.199	0.017
ECG	0.023	0.004	0.018	0.040	0.074	0.018	0.008	0.020	0.007	0.102	0.009	0.005	0.328	0.027
X-Ray	0.205	0.183	0.161	0.120	0.134	0.166	0.070	0.020	0.181	0.102	0.232	0.249	1.824	0.152
Ultrasound Machine	0.205	0.183	0.161	0.120	0.134	0.166	0.631	0.184	0.181	0.102	0.232	0.178	2.478	0.206
Centrifuge	0.005	0.020	0.006	0.040	0.074	0.055	0.008	0.020	0.020	0.080	0.011	0.007	0.347	0.029
Blood Pressure Modules	0.003	0.007	0.003	0.040	0.002	0.002	0.008	0.020	0.003	0.011	0.009	0.004	0.111	0.009
Sterilizer	0.205	0.183	0.161	0.072	0.134	0.166	0.023	0.061	0.141	0.102	0.077	0.249	1.575	0.131
Surgical Lights	0.114	0.102	0.125	0.051	0.104	0.129	0.010	0.037	0.101	0.102	0.011	0.036	0.922	0.077
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Table 5: Pairwise comparison of different medical devices with respect to criterion:safety

Safety	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Lights
Infant Incubator	1.000	3.000	0.333	9.000	1.000	0.143	9.000	9.000	7.000	0.333	9.000	7.000
Defibrillator	0.333	1.000	0.333	9.000	0.200	0.143	9.000	9.000	5.000	0.111	3.000	3.000
Treadmill	3.000	3.000	1.000	9.000	0.143	0.200	9.000	9.000	0.143	1.000	5.000	5.000
CT Scanner	0.111	0.111	0.111	1.000	0.111	0.111	0.333	0.111	0.111	0.111	0.143	0.111
Infusion Pump	1.000	5.000	7.000	9.000	1.000	0.111	7.000	7.000	0.333	0.111	5.000	0.143
ECG	7.000	7.000	5.000	9.000	9.000	1.000	9.000	9.000	5.000	0.143	7.000	5.000
X-Ray	0.111	0.111	0.111	3.000	0.143	0.111	1.000	0.111	0.111	0.111	0.143	0.143
Ultrasound Machine	0.111	0.111	0.111	9.000	0.143	0.111	9.000	1.000	0.200	0.111	3.000	0.333
Centrifuge	0.143	0.200	7.000	9.000	3.000	0.200	9.000	5.000	1.000	0.111	5.000	5.000
Blood Pressure Modules	3.000	9.000	1.000	9.000	9.000	7.000	9.000	9.000	9.000	1.000	9.000	9.000
Sterilizer	0.111	0.333	0.200	7.000	0.200	0.143	7.000	0.333	0.200	0.111	1.000	0.143
Surgical Lights	0.143	0.333	0.200	9.000	7.000	0.200	7.000	3.000	0.200	0.111	7.000	1.000
sum	16.063	29.200	22.400	92.000	30.940	9.473	85.333	61.556	28.298	3.365	54.286	35.873

Safety	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Lights	sum	prirites
Infant Incubator	0.062	0.103	0.015	0.098	0.032	0.015	0.105	0.146	0.247	0.099	0.166	0.195	1.284	0.107
Defibrillator	0.021	0.034	0.015	0.098	0.006	0.015	0.105	0.146	0.177	0.033	0.055	0.084	0.790	0.066
Treadmill	0.187	0.103	0.045	0.098	0.005	0.021	0.105	0.146	0.005	0.297	0.092	0.139	1.243	0.104
CT Scanner	0.007	0.004	0.005	0.011	0.004	0.012	0.004	0.002	0.004	0.033	0.003	0.003	0.090	0.008
Infusion Pump	0.062	0.171	0.313	0.098	0.032	0.012	0.082	0.114	0.012	0.033	0.092	0.004	1.024	0.085
ECG	0.436	0.240	0.223	0.098	0.291	0.106	0.105	0.146	0.177	0.042	0.129	0.139	2.132	0.178
X-Ray	0.007	0.004	0.005	0.033	0.005	0.012	0.012	0.002	0.004	0.033	0.003	0.004	0.122	0.010
Ultrasound Machine	0.007	0.004	0.005	0.098	0.005	0.012	0.105	0.016	0.007	0.033	0.055	0.009	0.356	0.030
Centrifuge	0.009	0.007	0.313	0.098	0.097	0.021	0.105	0.081	0.035	0.033	0.092	0.139	1.031	0.086
Blood Pressure Modules	0.187	0.308	0.045	0.098	0.291	0.739	0.105	0.146	0.318	0.297	0.166	0.251	2.951	0.246
Sterilizer	0.007	0.011	0.009	0.076	0.006	0.015	0.082	0.005	0.007	0.033	0.018	0.004	0.275	0.023
Surgical Lights	0.009	0.011	0.009	0.098	0.226	0.021	0.082	0.049	0.007	0.033	0.129	0.028	0.702	0.059
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Table 6: Pairwise comparison of different medical devices with respect to criterion:Recalls

Recalls	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Lights
Infant Incubator	1.000	0.333	7.000	0.111	1.000	0.200	0.111	0.143	3.000	9.000	0.143	0.143
Defibrillator	3.000	1.000	5.000	0.111	1.000	0.333	0.143	0.143	5.000	9.000	0.200	5.000
Treadmill	0.143	0.200	1.000	0.111	0.143	0.143	0.111	0.111	0.200	0.111	0.143	0.143
CT Scanner	9.000	9.000	9.000	1.000	7.000	5.000	0.143	5.000	9.000	9.000	5.000	7.000
Infusion Pump	1.000	1.000	7.000	0.143	1.000	5.000	0.111	0.111	0.200	7.000	0.111	0.200
ECG	5.000	3.000	7.000	0.200	0.200	1.000	0.143	0.111	1.000	7.000	0.143	3.000
X-Ray	9.000	7.000	9.000	7.000	9.000	7.000	1.000	3.000	7.000	9.000	3.000	3.000
Ultrasound Machine	7.000	7.000	9.000	0.200	9.000	9.000	0.333	1.000	9.000	9.000	3.000	7.000
Centrifuge	0.333	0.200	5.000	0.111	5.000	1.000	0.143	0.111	1.000	5.000	0.143	0.200
Blood Pressure Modules	0.111	0.111	9.000	0.111	0.143	0.143	0.111	0.111	0.200	1.000	0.111	0.111
Sterilizer	7.000	5.000	7.000	0.200	9.000	7.000	0.333	0.333	7.000	9.000	1.000	7.000
Surgical Lights	7.000	0.200	7.000	0.143	5.000	0.333	0.333	0.143	5.000	9.000	0.143	1.000
sum	49.587	34.044	82.000	9.441	47.486	36.152	3.015	10.317	47.600	83.111	13.137	33.797

Recalls	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pump	ECG	X-Ray	Ultrasound	Centrifuge	Blood Pressure Modules	Sterilizer	Surgical Lights	sum	pirites
Infant Incubator	0.020	0.010	0.085	0.012	0.021	0.006	0.037	0.014	0.063	0.108	0.011	0.004	0.391	0.033
Defibrillator	0.060	0.029	0.061	0.012	0.021	0.009	0.047	0.014	0.105	0.108	0.015	0.148	0.631	0.053
Treadmill	0.003	0.006	0.012	0.012	0.003	0.004	0.037	0.011	0.004	0.001	0.011	0.004	0.108	0.009
CT Scanner	0.181	0.264	0.110	0.106	0.147	0.138	0.047	0.485	0.189	0.108	0.381	0.207	2.364	0.197
Infusion Pump	0.020	0.029	0.085	0.015	0.021	0.138	0.037	0.011	0.004	0.084	0.008	0.006	0.460	0.038
ECG	0.101	0.088	0.085	0.021	0.004	0.028	0.047	0.011	0.021	0.084	0.011	0.089	0.590	0.049
X-Ray	0.181	0.206	0.110	0.741	0.190	0.194	0.332	0.291	0.147	0.108	0.228	0.089	2.816	0.235
Ultrasound Machine	0.141	0.206	0.110	0.021	0.190	0.249	0.111	0.097	0.189	0.108	0.228	0.207	1.857	0.155
Centrifuge	0.007	0.006	0.061	0.012	0.105	0.028	0.047	0.011	0.021	0.060	0.011	0.006	0.374	0.031
Blood Pressure Modules	0.002	0.003	0.110	0.012	0.003	0.004	0.037	0.011	0.004	0.012	0.008	0.003	0.210	0.017
Sterilizer	0.141	0.147	0.085	0.021	0.190	0.194	0.111	0.032	0.147	0.108	0.076	0.207	1.459	0.122
Surgical Lights	0.141	0.006	0.085	0.015	0.105	0.009	0.111	0.014	0.105	0.108	0.011	0.030	0.740	0.062
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Table 7: Pairwise comparison of different medical devices with respect to criterion: Availability of alternative devices

Availability o	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pum	ECG	X-Ray	Ultrasound Ma	Centrifuge	Blood Pressure	Sterilizer	Surgical Lights
Infant Incuba	1.000	0.333	5.000	7.000	0.111	0.333	7.000	7.000	3.000	0.111	7.000	7.000
Defibrillator	3.000	1.000	3.000	5.000	0.111	1.000	5.000	5.000	3.000	0.111	7.000	7.000
Treadmill	0.200	0.333	1.000	9.000	0.143	0.143	7.000	7.000	5.000	7.000	7.000	5.000
CT Scanner	0.143	0.200	0.111	1.000	0.111	0.111	0.333	0.333	0.143	0.111	0.333	0.143
Infusion Pum	9.000	9.000	7.000	9.000	1.000	9.000	9.000	9.000	7.000	1.000	7.000	7.000
ECG	3.000	1.000	7.000	9.000	0.111	1.000	5.000	5.000	7.000	0.143	7.000	5.000
X-Ray	0.143	0.200	0.143	3.000	0.111	0.200	1.000	3.000	0.333	0.111	0.333	0.143
Ultrasound Ma	0.143	0.200	0.143	3.000	0.111	0.200	0.333	1.000	0.143	0.111	0.333	0.200
Centrifuge	0.333	0.333	0.200	7.000	0.143	0.143	3.000	7.000	1.000	0.111	7.000	5.000
Blood Pressure	9.000	9.000	0.143	9.000	1.000	7.000	9.000	9.000	9.000	1.000	9.000	7.000
Sterilizer	0.143	0.143	0.143	3.000	0.143	0.143	3.000	3.000	0.143	0.111	1.000	7.000
Surgical Ligh	0.143	0.143	0.200	7.000	0.143	0.200	7.000	5.000	0.200	0.143	0.143	1.000
sum	26.248	21.886	24.083	72.000	3.238	19.473	56.667	61.333	35.962	10.063	53.143	51.486

Availability o	Infant Incubator	Defibrillator	Treadmill	CT Scanner	Infusion Pum	ECG	X-Ray	Ultrasound Ma	Centrifuge	Blood Pressure	Sterilizer	Surgical Lights	sum	pirites
Infant Incuba	0.038	0.015	0.208	0.097	0.034	0.017	0.124	0.114	0.083	0.011	0.132	0.136	1.009	0.084
Defibrillator	0.114	0.046	0.125	0.069	0.034	0.051	0.088	0.082	0.083	0.011	0.132	0.136	0.972	0.081
Treadmill	0.008	0.015	0.042	0.125	0.044	0.007	0.124	0.114	0.139	0.696	0.132	0.097	1.542	0.128
CT Scanner	0.005	0.009	0.005	0.014	0.034	0.006	0.006	0.005	0.004	0.011	0.006	0.003	0.108	0.009
Infusion Pum	0.343	0.411	0.291	0.125	0.309	0.462	0.159	0.147	0.195	0.099	0.132	0.136	2.808	0.234
ECG	0.114	0.046	0.291	0.125	0.034	0.051	0.088	0.082	0.195	0.014	0.132	0.097	1.269	0.106
X-Ray	0.005	0.009	0.006	0.042	0.034	0.010	0.018	0.049	0.009	0.011	0.006	0.003	0.203	0.017
Ultrasound Ma	0.005	0.009	0.006	0.042	0.034	0.010	0.006	0.016	0.004	0.011	0.006	0.004	0.154	0.013
Centrifuge	0.013	0.015	0.008	0.097	0.044	0.007	0.053	0.114	0.028	0.011	0.132	0.097	0.620	0.052
Blood Pressure	0.343	0.411	0.006	0.125	0.309	0.359	0.159	0.147	0.250	0.099	0.169	0.136	2.514	0.209
Sterilizer	0.005	0.007	0.006	0.042	0.044	0.007	0.053	0.049	0.004	0.011	0.019	0.136	0.383	0.032
Surgical Ligh	0.005	0.007	0.008	0.097	0.044	0.010	0.124	0.082	0.006	0.014	0.003	0.019	0.419	0.035
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Pairwise comparison between criteria:

It should be noted that when comparing the criteria and determining preference among them, made a questionnaire as follows:

Criteria	4	3	2	1	2	3	4	Criteria
Utilization				√				Utilization
Utilization						√		Failure frequency
Utilization		√						Cost of repair
Utilization		√						Downtime
Utilization							√	Safety
Utilization	√							Recalls
Utilization		√						Availability of alternative devices
Failure frequency				√				Failure frequency
Failure frequency						√		Cost of repair
Failure frequency						√		Downtime
Failure frequency							√	Safety
Failure frequency		√						Recalls
Failure frequency						√		Availability of alternative devices
Cost of repair				√				Cost of repair
Cost of repair	√							Downtime
Cost of repair							√	Safety
Cost of repair		√						Recalls
Cost of repair						√		Availability of alternative devices
Downtime				√				Downtime
Downtime							√	Safety
Downtime					√			Recalls
Downtime					√			Availability of alternative devices
Safety				√				Safety
Safety		√						Recalls
Safety	√							Availability of

								alternative devices
Recalls				√				Recalls
Recalls		√						Availability of alternative devices
Availability of alternative devices				√				Availability of alternative devices

Table 8: Pairwise comparison between criteria

	Utilization	Failure frequ	Cost of repair	Downtime	safety	Recalls	Availability c	priorities
Utilization	1	0.4285	0.2857	0.2857	0.8571	0.1428	0.2857	0.4691
Failure frequency	0.4285	1	0.714	0.714	0.8571	0.2857	0.714	0.6733
Cost of repair	0.2857	0.714	1	0.1428	0.8571	0.2857	0.714	0.5713
Downtime	0.2857	0.714	0.1428	1	0.8571	0.5714	0.5714	0.5917
Safety	0.8571	0.8571	0.8571	0.8571	1	0.2857	0.1428	0.6937
Recalls	0.1428	0.2857	0.2857	0.5714	0.2857	1	0.1428	0.3877
Availability of alternative device	0.2857	0.714	0.714	0.5714	0.1428	0.1428	1	0.5105
	3.2855	4.7133	3.9993	4.1424	4.8569	2.7141	3.5707	

	Utilization	Failure frequ	Cost of repair	Downtime	safety	Recalls	Availability c	priorities
Utilization	0.3	0.09	0.079	0.069	0.18	0.05	0.08	0.12
Failure frequency	0.13	0.21	0.17	0.17	0.18	0.11	0.2	0.16
Cost of repair	0.08	0.15	0.25	0.033	0.18	0.11	0.2	0.14
Downtime	0.08	0.15	0.035	0.24	0.18	0.21	0.16	0.15
Safety	0.26	0.18	0.21	0.2	0.2	0.1	0.04	0.17
Recalls	0.04	0.06	0.07	0.14	0.05	0.37	0.04	0.11
Availability of alternative device	0.13	0.15	0.177	0.14	0.03	0.05	0.29	0.14
								1

The last table represents the criteria comparison table, and this table represents the amount of what the criteria means to the other in terms of priorities, as note After the mathematical operations that have done which is adding the numbers in each column then divide each cell by the sum have a new table and new mathematical operations have been applied to it which is adding all the rows and dividing them by their number so have a number in the priorities, this number determines the priority of the criterion.

Results:

Table 9: Pairwise comparison between device criteria

	Utilization	Failure frequ	Cost of repair	Downtime	safety	Recalls	Availability c	priorities
Utilization	0.3	0.09	0.079	0.069	0.18	0.05	0.08	0.12
Failure frequency	0.13	0.21	0.17	0.17	0.18	0.11	0.2	0.16
Cost of repair	0.08	0.15	0.25	0.033	0.18	0.11	0.2	0.14
Downtime	0.08	0.15	0.035	0.24	0.18	0.21	0.16	0.15
Safety	0.26	0.18	0.21	0.2	0.2	0.1	0.04	0.17
Recalls	0.04	0.06	0.07	0.14	0.05	0.37	0.04	0.11
Availability of alternative device	0.13	0.15	0.177	0.14	0.03	0.05	0.29	0.14
								1

	Utilization	Failure frequ	Cost of repair	Downtime	safety	Recalls	Availability c	final results
	0.12	0.16	0.14	0.15	0.17	0.11	0.14	
Infant Incubator	0.09924	0.068	0.055	0.052	0.107	0.033	0.084	0.065
Defibrillator	0.188913	0.012	0.029	0.032	0.066	0.053	0.081	0.062
Treadmill	0.007957	0.029	0.036	0.026	0.104	0.009	0.128	0.051
CT Scanner	0.201971	0.028	0.238	0.241	0.008	0.197	0.009	0.122
Infusion Pump	0.043254	0.241	0.016	0.017	0.085	0.038	0.234	0.100
ECG	0.058409	0.159	0.036	0.027	0.178	0.049	0.106	0.092
X-Ray	0.128042	0.041	0.194	0.152	0.010	0.235	0.017	0.102
Ultrasound Machine	0.11081	0.025	0.159	0.206	0.030	0.155	0.013	0.095
Centrifuge	0.017627	0.036	0.021	0.029	0.086	0.031	0.052	0.040
Blood Pressure Modules	0.015003	0.123	0.024	0.009	0.246	0.017	0.209	0.099
Sterilizer	0.080424	0.193	0.137	0.131	0.023	0.122	0.032	0.101
Surgical Lights	0.048349	0.045	0.056	0.077	0.059	0.062	0.035	0.054
								1.000

On the basis of the previous table the criteria comparison table was extracted according to the following equations:

Final result for infant incubator

(0.09924*0.12+0.068*0.16+0.055*0.14+0.052*0.15+0.107*0.17+0.033*0.11+0.084*0.14)

= 0.065

Difibrilator = 0.062

Treadmill = 0.051

Ct scanner = 0.122

Infusion pump = 0.1

ECG = 0.92

X-Ray = 0.102

Ultrasound = 0.095

Centrifuge = 0.040

Blood Pressure Modules = 0.099

Sterilizer = 0.101

Surgical Lights = 0.054

Note in the previous table that there are some important criteria that have been adopted for many medical devices, which is the highest rule on the basis of which the device is chosen or classified as having priorities for presence, maintenance, or has no priorities As seen in the table the CT machine have had the greatest share of interest and progress in maintenance also note that there are some medical devices that have received more attention and the preference is higher, such as the x-ray machine and the ultrasound machine. Through this table it became clear to us that the lowest device is the centrifuge, which did not take preference. He hasn't taken a high priority in comparison, and thus tends to be something he needs more quickly doing his maintenance in the hospital.

In the beginning made a questionnaire containing 7 criteria, and this questionnaire was filled out by specialists in medical devices to make a comparison between the devices on the basis of the critiria so had 7 questionnaires filled out in different ways and places and on the basis of these questionnaires the AHP method was followed in order to make a comparison between them as shown to us Above laws were followed in order to transform this comparison into numbers through which can complete the work, and all of it was clarified in the foregoing. As for the first table, it was made on the basis of the questionnaire as it contained the square between the device and its counterpart on the number 1 and thus made a diagonal line containing the number 1 This is explained above.

As for the second table, it was filled in on the basis of the first table by adding every column and dividing each cell in the first column by the sum, and this is what you continue to do with all the columns. Even in the end can reach the number that relates to priority as note that the basis of priority was based on collecting all the rows together and dividing it by 12 which is the number of devices that wanted to make a comparison between them.

In the end made another questionnaire related to the comparison between the criteria, and on the basis of this questionnaire a table was made that follows the previous method to reach the criteria comparison table and determine the priority from them.
Where graduated in colors from red to green, passing through yellow in between Red is the lowest priority critiria yellow is medium priority and green is the highest priority.

Through this work and following the steps of AHP to set priorities and make these tables, the method was followed literally where at the beginning the problem was identified then critiria were created questionnaires were made and information was collected from the specialists then after that a table of priorities was made based on any existing laws and then a table was made to determine the priorities of the criteria that were These questionnaires represent the pairwise comparison through which compare the relative importance of each of the other criteria, and this was done as noticed through the scale of numbers from 1-9 after which calculated the weights using these questionnaires, and in the end as noticed the colors determine the priority over the other as shown.

Conclusion:

In conclusion talk about everything that was done in this project with the benefit of it, and here our team made questionnaires and followed the AHP method in order to determine the appropriate criteria and draw priority tables based on these criteria, and thus determined the priorities of the devices.

Then can now make the decision regarding these devices in relation to the specified criteria, and the benefit of this plan is to determine a way to do the maintenance without getting lost or making a wrong decision that is not in the interest of the work and may have not good results.

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