

Proper Optimization Strategy for Donated Medical Devices in Yemeni Governmental Medical Sectors

Saeed H. Bamashmos¹,
Ahmad N. Al-naggar¹,
Wail Alhakimi¹,

¹Lebanease International
University, Yemen

Mohamad Abou Ali²
²Lebanease International
University, Lebanon

Abdallah Kassem³ ³Notre
Dame University-
Louaize,
Lebanon

Abstract— It is commonly stated that the majority of donated medical equipment in underdeveloped countries like Yemen is dysfunctional due to bad medical device management strategies, with estimates ranging as high as 80% out of service. However, there is little written evidence to substantiate these claims. Many literature reviews were collected to prove this issue in low- and middle-income countries that have mismanagement of donated devices, due to poor infrastructure, shortage of spare parts, lack of proper maintenance training, and lack of E-Government platform. The aim of this study is to determine the quantity of donated medical equipment that is no longer in use in Yemeni government hospitals and identify possible causes. The researcher uses a structured interview method with the person who uses these devices in the hospitals like biomedical engineers, maintenance engineers, technicians, and inventory managers to significantly address the issue of having donated devices out of service and what may be the best practice solution to get them back to service. This information will be then analyzed and proper recommendations will be introduced to the Ministry of Health and Housing to guide governmental hospitals to the proper optimization of the donated medical equipment.

Keywords—Donations _ Technology _ Strategy _ Decision making _ Medical equipment _ Health sectors _ E-Government

I. INTRODUCTION

Along with global health inequities, many low- and middle-income countries face shortages of essential medical devices and medical supplies. External governments or non-governmental organizations (NGOs) make grants to countries or individual health facilities to address these inequalities. The delivery of modern health care, including health-care devices, is highly reliant on technology. Many underdeveloped countries like Yemen health sectors are forced to rely heavily on equipment donations due to financial constraints. Nearly 80% of health-care equipment is donated or provided by international donors or foreign governments in certain countries (Dyro, 2004). While most donations are made with good intentions, if they are not well organized and arranged, the results are not always positive.

The implementation, use, and maintenance of health-care equipment necessitate substantial financial, operational, and human capital. Regrettably, this is not always completely appreciated. According to WHO (WHO, 2000) only 20% of donated equipment is operational in developing countries. Mismanagement in the technology procurement process, a lack of user training, and inadequate technical support are all explanations for unused equipment. When performed correctly, medical device donation initiatives have the ability to increase healthcare access in some of the world's poorest areas. However, poorly implemented donations can cause damage and stress recipient countries.

Medical equipment is widely used in the diagnosis and care of patients. In today's world, providing health services through the use of diagnostic and treatment devices is a critical component of health care, especially in hospitals (Wang, 2008). Medical devices are assets that directly improve the quality of life for many people (Painter, 2011). Clinical engineers are in charge of medical devices that include calibration, servicing, repair, user training, and decommissioning.

Depending on a field site visit conducted it is found that many of the donated medical device in more than five main governmental health care facilities in Sana'a, Yemen was out of service or broken, and due to this the medical device is thrown in bad conditioned and ignored hospital store environment.

This study best practices and considerations are intended to enhance the efficiency of donated medical equipment use and identify the constrains faced by healthcare facilities regarding spear parts, consumables, and training of proper medical device use in the first place, then providing maintenance to out of service. This can provide recommendations on the proper optimization of donated medical device in Yemeni medical sectors and to the Ministry of Health and Housing.

These factors may be used to establish medical equipment donation policies and regulations at the institutional and national levels. These considerations can be applied anywhere, but they may be particularly useful for health systems in developing countries that rely heavily on donations. While this study focuses on medical equipment, many of the considerations relate to other forms of donations as well, such as medical supplies and consumables.

II. FACTORS INFLUENCING THE PROPER OPTIMIZATION OF DONATED MEDICAL DEVICES IN UNDERDEVELOPED COUNTRIES MEDICAL SECTORS.

As it is collected from the literature reviews of this issue the study can identify an internal and external factor for the best optimization of donated medical devices, thus the study can explain them as follows:

A. Internal Factors

All underdeveloped countries medical facilities have problems with the donated device, starting with their infrastructure, these hospitals are not prepared well to maintain those donated device, and by this the study can define several criteria:

1) Power Source Stabilities and Reliability.

Although health-care technologies have improved steadily in developed countries, developing countries have yet to reap the full benefits of this progress. Many electric medical devices fail due to a variety of factors, including unreliable power sources, inappropriate technologies, and a lack of maintenance (Adair-Rohani, 2013). Normal blackouts, in particular, result in repeated unavailability of medical equipment and health facilities, whereas electrical surges and transients can destroy several devices. According to a vast study based on data collected from 33 hospitals in 10 developing countries (Malkin R. , 2007), “The most common single cause of failure was the power supply (29.9%)” on a total of 975 pieces of damaged equipment. As a result, a safe and sustainable energy supply is part of the global slogan "Health for Everyone in the Third Millennium."

Despite this, most programs aimed at improving hospital infrastructure in developed countries have concentrated on medical equipment or providing certain electricity generation systems for those who are not linked to the national electricity grid. In a similar vein, the majority of the few research on electricity supply in Sub-Saharan hospitals concentrate on the number of hours with access to energy rather than the efficiency and reliability of the electricity. This is a challenge because power outages affect the long-term viability and efficiency of medical care, as well as a population's health and well-being. This, in turn, has an indirect effect on school attendance (and therefore education level), as well as the national economy, since working population ability is reduced (Ngounou, 2014).

2) Medical device occupying environment.

Understanding the differences between cleaning, disinfection, and sterilization is critical when determining the amount of decontamination necessary for a certain medical equipment.

Cleaning, the elimination of bodily materials, dust, or alien matter by physical means. Cleaning reduces the quantity of microorganisms and soil on the surface being disinfected or sterilized, allowing for better contact and minimizing the danger of soil adhering to the surface. The chance of a chemical disinfectant becoming inactive and germs multiplying is also reduced when dirt is removed. Contamination is removed from an object to the amount required for continued processing or intended usage (PAHO, 2016).

Disinfection, microorganisms are destroyed or removed at a level that is not damaging to health and is easy to handle. The elimination of bacterial spores is not always part of this process. Sterilization, The complete destruction or removal of microorganisms, including bacterial spores. Sterility state of being free from viable microorganisms. Sterilization validated process used to render a product free from viable microorganisms (PAHO, 2016).

3) Hospital Medical Equipment Maintenance Management.

Medical equipment management specialists ensure that the equipment used in patients' care is operational, safe, and properly configured to meet the medical treatment facility's mission, as well as that it continues to function effectively and in good working order. Proper maintenance, for example, can extend the life of equipment. This is critical for providing high-quality health care while conserving limited resources. Medical equipment management, on the other hand, encompasses a wide range of operations that guarantee that equipment is properly planned, budgeted, acquired, and operated, among other things (Usdin M, 2006).

Hospitals employ human factors engineering to impact maintenance and medical equipment purchase choices. The procedure guarantees the acquisition of the safest, most efficient, and effective maintenance instruments and gadgets. When used to the design and assessment of medical devices, human factors engineering is commonly highlighted as a significant strategy for reducing medical error and adverse occurrences while also increasing patient safety (Usdin M, 2006).

B. External Factors.

When talking in the external factor the study concentrate in the donor part of the problem, when accruing a donation the donor should at least know that this countries are poor enough to provide a training service for the device in the part of installation of medical device or maintenance, let alone providing spare parts for such advanced device, the study can summarize those factors to be:

1) Spare Parts

The shortage of spare parts in the underdeveloped countries is the most significant design hurdle. Any computer intended for use in developed countries is likely to fail as soon as the first repair component is required. If a filter has to be changed every six months, for example, the unit would most likely only last six months in a developing-world hospital. This may be due to a lack of replacement parts in the developed world, the fact that the parts are no longer manufactured, or the fact that the item requires the use of a credit card to buy (few people in the developing world own a credit card) (Malkin R. , 2007).

Recent research shows (Malkin R. , 2007), however, that the shortage of replacement parts is overly frequently cited as a concern. Just 12.3% (120 out of 975) of the damaged pieces of equipment reported by participants in the Engineering World Health (EWH) study needed a replacement component that could not be produced or assembled in the developed world. As a result, the scarcity of spare parts can be a minor issue compared to what is commonly assumed. There are other reasons why pieces struggle to be replaced. The cost may be prohibitive, or the hospital may lack the necessary expertise or equipment. A technician with more than a high school diploma is rare in most hospitals.

The hospital may believe that the spending is a waste of money in some situations. According to a EWH survey, a hospital found it cheaper to order a new oxygen concentrator from their European sponsor than to pay the \$5 needed to replace the concentrator they already had (Malkin R. , 2007). Another problem with electronic components in developed countries is a shortage of technical personnel who are inspired. Staff anger was cited by several participants in the EWH sample as a factor in their inaction (Malkin R. , 2007). Frustration may be caused by a shortage of resources and manuals, as well as political corruption, which can spread to public hospitals or organized biomedical engineering facilities. Because of their dissatisfaction, technicians may decide not to attempt a repair or maintenance operation.

2) Consumables

The shortage of consumables is one of the most common issues in developing-world hospitals. Consumables are materials or components that are used for the use of the machinery but can only be reused once or twice (e.g., test strips, ECG electrodes, blood pressure transducers or electro-surgery tips). Most of the time, the item is clearly unavailable in the world (Malkin R. A., 2007).

Specific consumables cannot always be avoided, and common consumables must be packed in specialized packages in certain instances. The packages or specifications, on the other hand, are often introduced as part of an economic model (the color printer is inexpensive, but the toner cartridges are expensive). One of the most common obstacles to the purchasing

of medical supplies by developed world hospitals or donating organizations is the failure to provide replacement consumables.

3) Inventory Management

Health-care technology has become a vital component of care because it allows physicians to diagnose, treat, track, and provide counseling to patients in a safe and effective environment. Health-care infrastructure quality control ensures that these programs are delivered in a secure and efficient manner. The first step in health-care technology management is to figure out what needs to be managed and build a health-care technology inventory.

The inventory is a living document that is reviewed and updated on a regular basis to ensure that the state of healthcare technology assets is accurately reflected. When used correctly, the inventory can be a valuable and effective method for bettering the management of many critical aspects of health-care technology (WHO, 2011).

A medical equipment inventory can aid in the identification of spare parts and consumables needed to keep the machine working. Inventory of spare parts and consumables alerts the team to purchase stock so that existing reserves aren't exhausted and service isn't interrupted. The primary goals are to calculate consumption rates (number of parts per unit of time) and to set a reorder standard that is adequate to sustain operation over the time it takes to order and receive new parts. Item stock quantities are never exhausted when properly handled, and operation is never disrupted (WHO, 2012).

Any health-care facility should evaluate its needs so that it can act effectively to deliver the services and procedures that are specified within the facility's framework. This assessment also requires the forms and amounts of equipment used to successfully carry out these treatments. This list will also be applied to the actual inventory to locate equipment inventory shortages and surpluses, as well as plan how to better fulfill the organization's needs. Inventory shortages may be quantitative (not enough computers to satisfy patient demand) or relational (not enough machines to meet patient demand) (relating to performance, integrity, reliability and functionality of the equipment). This needs evaluation will be used to prepare for new equipment purchases or to compile donor "wish lists" to collect appropriate donations (WHO, 2012).

A piece of equipment has a set lifespan and may need to be replaced or discarded at some point. When equipment is no longer serviceable, appropriate, reliable, or cost-effective, over history associated with inventory items may be evaluated. Trends over time can assist in determining the projected lifespan of equipment as well as the cost-effectiveness (or lack thereof) of keeping a piece of equipment in operation. This data will be used to create strategies for equipment replacement and disposal. This knowledge will then be used to create estimates for new capital investments, maintenance programs, and other expenses (Kaur, 2005).

When equipment has to be removed or disposed of, it is usually purchased or donated. The health-care facility will classify equipment that it requires to purchase by tracking inventory levels and patterns over time and conducting a needs review of appropriate technology. This data will be used to create a buying strategy, defining essential equipment that must be acquired immediately and setting procurement targets for the future. If infrastructure is found to be missing, it will be attached to a donor wish list, which can then be sent to charitable organizations to promote valuable and appropriate donations (Kaur, 2005).

III. METHODOLOGY

The study architecture, population and sampling methods used, instrumentation, data processing, the scale of validity and reliability, as well as the data analysis process will be furthermore explained here. The data collection was done in a structured manner, and the study was done using the Statistical Package for the Social Sciences (SPSS) software for an appropriate analysis of the data collected.

A. Research Design

A research design is a strategy for gathering data, measuring it, and analyzing it in order to address the research question (Sekaran & &, 2016). This study uses a structured interviews design. Structured interviews are those in which the information required is identified from the start.

The analyst takes notes as the respondents share their opinions. All will be asking the same questions in the same way. However, depending on the circumstances, an experienced researcher might take a cue from a respondent's response and ask additional pertinent questions not included in the interview procedure.

B. Population and Sampling

The population in this study is the all personnel that works with donated medical devices in Yemeni governmental hospitals, these personnel are Hospital Managers, Biomedical Engineering Divisions, Maintenance Divisions, Doctors, Local clinical heads, Devices Operators, Technicians, Inventory Divisions. Number of 20 governmental hospital were covered in different rural an urban Yemeni province.

The researcher chose the personnel that deals with the donated medical equipment in order to collect their perspectives in dealing with the equipment and know what are the main reasons, based on each part perspectives, that make the donated equipment out of service. In addition, the researcher understands the main difficulties and issues that the personnel face when using the donated devices, the population was chosen in order to investigate the effect of the factors that influence the proper optimization of donated medical devices.

Purposive judgmental sampling was used to select the sample frame, since it is limited to certain persons who can provide the sought-after material, the sampling is purposive. Since they are the only ones who meet the researcher's standards, such entities are the only ones who provide this knowledge or can have the desired information.

C. Data Collections

A structured interview is a dialogue in which an interviewer poses a list of questions to an interviewee in a predetermined order. The interviewee gathers the candidate's answers and grades them using a ranking scale. Interviewers may gather related categories of information conveyed in a uniform context by asking the same questions in the same order.

D. Scale of Validity and Reliability

The use of better instruments ensures the precision of test findings, which contributes to an improvement in the research's analytical efficiency. The researcher wanted to make sure that the instruments used in the study correctly measured what they were designed for. As a result, a validity and durability evaluation was conducted, people with different background in donated device from WHO, governmental hospital, expert biomedical engineers along with technician and maintenance staff were asked to judge on the interview questions. All their response and modifications of the questions were took in to consideration before it was used for the interview.

IV. RESULTS AND DISCUSSION

The results of the interview were collected and introduced into SPSS, a strong statistical analysis and data management application. Each of the six parameters had histograms created for it.

- Power source stabilities and reliability.
- Medical device occupying environment.
- Hospital Medical Equipment Maintenance Management.
- Spare parts.
- Consumables.

- Inventory management.

1. Power Source Stabilities and Reliability

While health technology has improved steadily in developed nations, underdeveloped countries have been unable to fully benefit from this advancement, owing in part to unreliable power sources. Grid failures are responsible for one-third of medical device failures, according to a World Health Organization study. As a result, the global slogan "Health for All in the Third Millennium" necessitates a stable and long-term supply of electricity in hospitals.

The combined percentages mean ratings for generator, central power supply source were 90, 10 percent respectively, these indicates that most Yemeni hospitals are depending on generators for their power supply, here it is important to consider problems associated with power generators when it comes to medical equipment failure due to the instable power supply generated.

It is well known that power generators are supposed to be as a backup solution for the central power supply in all hospitals, but in Yemeni hospitals and due to the war case that Yemeni is facing since 2014, the central power supply is off in many provinces, add to this the bad recourse of the fuel used in this generator that make it cut service many times per month, as it was seen from the results of "How often have power outages happened in the last month?", the combined The combined percentages mean ratings for power cutoff of 1-3 times per month, 4-6 times per month, 7-10 times per month and more than 10 times per month was 9.7, 45.2, 32.3, 1.9 percent respectively, this can show that the greater percentage was for 4-6 times per month which for a healthcare device this is critical, power generators are reliable when it comes in a country like Yemen that suffers from fuel supply shortage.

2. Medical Device Occupying Environment.

Cleaning refers to the removal of visible dirt, dust, and debris in a healthcare setting. Cleaning alone reduces environmental pollution significantly, including the eradication of numerous diseases.

When it comes to Yemeni medical sectors environment it is shown that it is full of dust due to unreliable cleaning frequency per week in the sector, taking into consideration the insulation or distance from dust the results showed that only 30% of the response where stating that it is good, and the rest 70% where between poor and accepted which in medical sectors this is not acceptable at all, medical device are very sensitive to any dust particles and the environment should always be kept clean.

Other factor to consider in the medical device environment is the ventilation and air flow in the room, since these devices are sensitive to temperature change and they have a high rate of heat when on service, the results were 50% for accepted, 30% to be poor, 10% very poor, and only 20% response were good, medical device should be occupied in a good ventilated environment to prevent breakdown or mistakes in diagnose from this medical due to sensitivity to heat change.

3. Hospital Medical Equipment Maintenance Management.

Maintenance management necessitates close oversight by healthcare managers who may lack the technical knowledge necessary to comprehend all pertinent issues. Since medical devices are affected every medical sector should have a center of training program for medical equipment usage and maintenance. This training program must cover all inspection procedures, preventive maintenance procedures, and corrective maintenance procedures for the donated medical devices, when this was measured the results showed that 80.6% of the response were that the medical sector do not provide training program for medical equipment, where training on

donated medical device is heavily of 83.3% depending on the donor party, and this training only offered technical training regarding the installation of donated medical device only, none of the inspection, corrective or preventive maintenance were given.

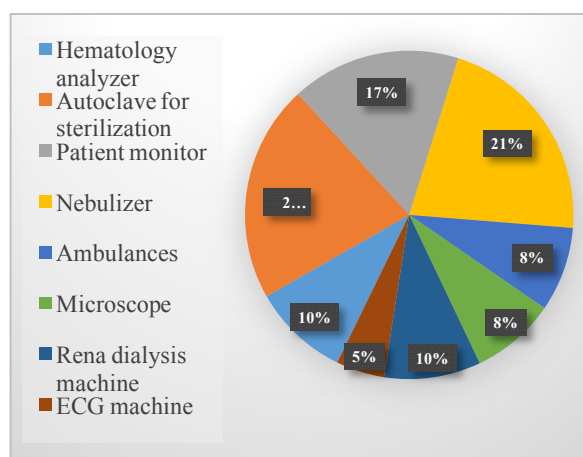


Figure 1: Frequency of recently donated medical equipment in in Yemeni Governmental Medical Sectors

4. Spare Parts.

The most major design challenge in developing nations is a lack of replacement components. Any computer designed for usage in developed countries is almost certain to fail as soon as the first repair component is needed. The study result regarding the shortage of the spare part is the highest, it is found that a high percentage as 92% of why donated medical devices are out of service is because they couldn't find its spare part easily locally, and if they are going to order for it is way expensive for the hospital.

The following table chart shows the donated medical device that are out of service waiting for spare part maintenance process:

Table 1: Out of Service Donated Medical Devices due to Shortage of Spare Parts

	FREQUENCY	VALID PERCENT	CUMULATIVE PERCENT
AUTOMATED ELISA	2	2.1	2.1
ANESTHETICS MACHINE	5	5.2	7.2
HEMATOLOGY ANALYZER	3	3.1	10.3
OXYGEN CONCENTRATOR	2	2.1	12.4
CLINICAL CHEMISTRY ANALYZER	3	3.1	15.5
VENTILATOR	6	6.2	21.6
AUTOCLAVE FOR STERILIZATION	16	16.5	38.1

NEONATAL INCUBATOR	5	5.2	43.3
PATIENT MONITOR	12	12.4	55.7
MICROSCOPE	11	11.3	67.0
NEBULIZER	12	12.4	79.4
AMBULANCES	7	7.2	86.6
RENA DIALYSIS MACHINE	8	8.2	94.8
ECG MACHINE	5	5.2	100.0
TOTAL	97	100.0	

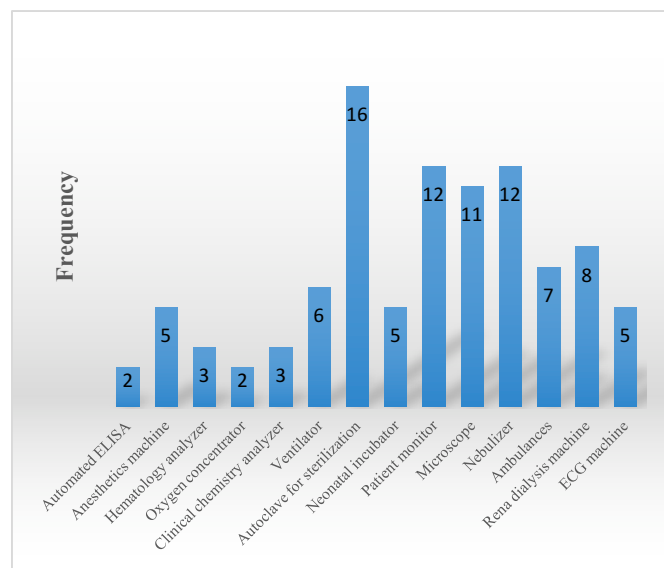


Figure 2: Chart View of Table

5. Consumables.

Syringes, needles, sutures, staples, packing, tubing, catheters, medical gloves, gowns, masks, adhesives and sealants for wound dressing, and a whole host of other devices and instruments needed in a hospital or surgical environment are all examples of medical consumables and equipment.

These tools are very important for some medical devices like ECG and others, sometimes the device is said of no use is these consumables are not present. There is a huge shortage when it comes to the local market consumables provider, the study results as shown is found:

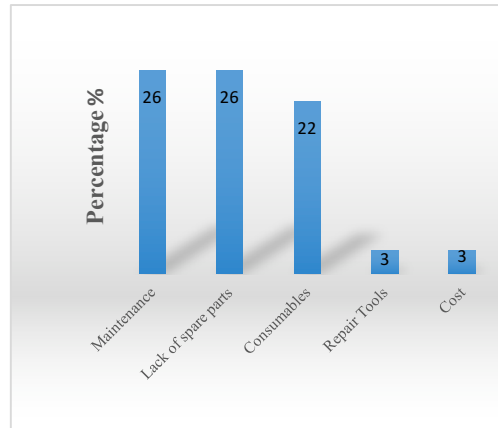


Figure 3: Difficulties in Getting Repairs to Equipment

6. Inventory Management.

Inventory management is very important when it comes to healthcare sector, it gives detailed information about the medical device in use, and it can be used as indication to any failure of the medical equipment. All Yemeni medical sectors use computers to save the data base, the quality of using this data base and updating it is found to be 62.1% to be acceptable, 27.6% to be good, and 10.3% to be very good.

These results are as expected but it is not always easy for the donors to have access to because of the lack to E- Government plat form regarding the medical devices in all governmental sectors, since this information can help reducing errors when it come to the standard followed by donors in the time of the donation process.

V. RECOMMENDATIONS AND CONCLUSION

Medical equipment management, which encompasses selection, purchasing, installation, and maintenance, is critical for assuring service readiness and having a positive influence on health care safety and efficacy. It extends the equipment's life and offers vital information for equipment management. The results of the data collection indicated that Yemeni governmental medical sectors did not have effective medical equipment management.

In order to enhance this management several reconditions are proposed regarding all the aspects that has to do with the improvement of the proper optimization of donated medical devises.

Regarding the power source, the medical sectors are recommended to rely on central power source and put generators in the state of backup, nowadays in Yemen we have commercial power source with the same effectiveness of the old before war state central power source, and this can solve a lot of cutoff and non-stabilized electrical source problems, saving the medical equipment from breaking out.

For the facility environment and cleaning, it is always recommended to add the times of cleaning with more disinfection materials for insuring a safe and clean environment. Moreover, it is useful to use negative pressure airflow source in the entrance of the sectors to prevent dust and dirt from entering this facility, by which keeping equipment clean and increase the lifetime service of it.

Serious review on hospital medical equipment maintenance management is needed, it is not recommended that the facility only relay on the donor training of medical device, since the training provided from the donor is only on how to install the device and prepare it to work, all aspects of maintenance like inspection, corrective and preventive maintenance should be considered to insure the proper work of the devices.

Furthermore, the facility is recommended to establish a maintenance center and fully prepare it to cover all kind of training from tools, trainers, and use it to have partnership training with the donor, not to forget that donor must be asked to provide service manual in order for the biomedical engineers to be able to fix the device in case of braking dawn.

When it comes to spare part, the facilities are recommended to prepare a list of spare parts for any device that is will be donated to them, the facility must use the data base it has to properly know what spare parts are needed, not only for the device that will be donated but also for the broken one they have in the inventory.

In case of a sudden failure of the device, the facility is recommended to have a list of local suppliers that have spare parts for the same edition devices like the donated one, if not thy should address this issue to the Ministry of Health and provide a detailed list of the spare parts needed, and the Ministry will add it to the list of medical equipment needed to the donor organizations like WHO and they will be more than welcome to provide the spare part, for this will lead to the improvement of all governmental facilities which is one of the most priority aim of this organizations to fulfil.

Same goes for the consumable part, it is recommended to be in advance prepared with the donation, since some consumables are essential for the device to operate well. Local suppliers can help hereto, the facility is highly recommended to inform the suppliers of the device donated type and provide the serial number of all donated device in order for the suppliers to have the consumables ready in their stock for future need of the facility.

Governmental hospitals along with Ministry of Health and Housing are recommended to have a E- Government plat form regarding all medical devices, donors should have access to the database regarding the consumables status in the hospital.

The last recommendation is regarding the inventory database management, the facility is recommended to always update this database with all aspects and issues of medical device, not only this, but also establish with the help of the Ministry of Health an online plat form of data base that all donors can access and review in order to have a good management when it comes into the decision making of donation procedures.

For the future work that can be done to this research, the slandered followed by the Ministry of Health should be reviewed and well prepared, for this can help overcoming many issues regarding the donation of the medical devices and their proper optimization in all governmental Yemeni sectors.

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