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ORIGINAL PAPER

Assistant computer program for adequate disposal of medical devices

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Abstract
In developing countries, up to 80% of medical equipment comes from donation. The World Health Organization (WHO) has made recommendations on desirable factors that should be taken into consideration when donating medical technology. We included these recommendations while building the Assistant Program for Adequate Disposal of Medical Devices (APAD) using the application generator App Building by MATLAB. We evaluated thirty units of medical equipment from different areas of a secondary health care level hospital. The Instrumentation Technician (IT) (expert) previously defined if the medical units were suitable to be donated, could be repaired, could be used as reservoir, or should be completely removed. APAD also made a proposal of the possible use of this technology. In 23 out of 30 medical units, the decision made by the APAD matched with that of the expert: seven for donation, eight to be repaired, two to serve as reservoir and six for disposal. Our results suggest that APAD could serve as a support tool for the IT and for the Biomedical Engineering Department in a hospital, to determine the possible use of medical equipment that has been discarded.

Keywords Medical equipment · Disposal · Computer program · Donation

1 Introduction

According to the World Health Organization (WHO), medical devices are essential for health preservation [1]. The Center of Excellence in Health Technology (CENETEC) in Mexico defines medical equipment as a device used in prevention, diagnosis, and rehabilitation of disease or injury. Medical equipment requires maintenance, calibration, repair, decommissioning and removal; in developing countries such activities are usually managed by a biomedical engineer [2].

Lifespan estimation of a medical device depends on several factors: frequency of use, environmental conditions, user experience, care and maintenance, availability, maintenance costs, availability and cost of supplies and spare parts, economic risks, electrical safety, political risks, compliance with current regulations, and funding availability. The American Hospital Association (AHA) defines an estimated lifespan from 10 to 25 years of a list of medical equipment [3]. The estimation is based on information provided by the manufacturer [4].

The Management Cycle of Medical Devices (MCMD) is a set of procedures that guarantee medical technology to be pertinent, safe, efficient, and cost-effective in the National Health System. Its main goal is to accomplish an adequate incorporation and operation of healthcare technology. The main goal of the MCMD consists of five stages: planning, acquisition, installation, operation, and disposal (removal). During the last stage, special measurements must be taken to protect users and the clinical environment from corrosive and/or toxic materials or loose parts. The decision to remove a medical device imply technical and financial ponderation. The causes of disposal must be explicitly described in the Technical Disposal Report, which is a document generated when an asset must be removed physically and financially from the inventory [5]. If the lifespan of the medical equipment has not concluded, donation to a different hospital may be considered [6, 7].

In developing countries, medical equipment donations are common. Up to 80% of the healthcare devices found

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in medical services come from a donation. However, only 10 to 30% of this equipment operates adequately. This could be caused by management and planning deficiencies, lack of trained users, and lack of adequate technical services. To avoid donations from being harmful to the recipient, different suitability factors must be considered. These factors are:

- Location: compatible with power supply and electrical system, compatible with weather conditions, able to work with local resources and low expenses.
- Quality and safety: manufactured under international safety standards by an authorized manufacturer or supplier.
- Cost-effective: affordable cost of installation, initialization, user training, maintenance, consumables, and accessories.
- Easy to use and maintain: manuals provision, and available assistance services.

Additionally, a continuous communication between the donor and the recipient is mandatory, as well as post-reception report. If the donation does not comply with the proper requirements, the recipient must be able to refuse it at any step of the process [8].

2 Methodology

The computer program that we built consists of ten sections. It includes the most important features that describe the technical and functional status of medical equipment. APAD suggests a possible use of medical technology after decommissioning, based on the information provided by the IT technician to the program. Each set of questions asked by the program are divided in sections. According to the answer, a certain amount of points (from one to seven, with one considered the most desirable characteristic and seven the least desirable for conservation) adds to a global sum. The name and maximum score that may be obtained in each section are listed below:

1. About the equipment, 25 points
2. Spare parts, 26 points
3. Consumables, 26 points
4. Accuracy and calibration, 11 points
5. User and training, 10 points
6. Maintenance, 16 points
7. Facilities, 33 points
8. About the provider, 16 points
9. Lifespan, 21 points
10. Electrical safety, 21 points

The displayed result by APAD may be Donation (sum 24-40 points), Reservoir (sum 41-60 points), Repair (sum 61-90 points), or Removal (sum 91-134 points).

We tested the first version of APAD in 30 units of medical equipment of which the IT had already determined their post-decommission use. Adjustments were made to APAD section scores until 20 units matched the expert's opinion. These tests were conducted in a private hospital in Toluca Valley, Mexico. We built APAD with the MATLAB® App Building tool. APAD interface shows multiple choice questions in each section. It takes around 5 min to answer the questionnaire completely.

3 Results

APAD is built following the structure shown in Fig. 1:

We tested APAD in 30 units of medical equipment provided by the hospital. These were: one tissue processor, one electro-stimulator, one call console, two digital thermometers, one negatoscope, one vital signs monitor, one wheelchair, one washable toilet, one irrigation pump, two steam autoclaves, one electrosurgical unit, one laparoscopy tower, one craniotome, one heat nebulizer, two incubators, one sterilizer, two mechanical ventilators, one infusion pump, one coagulation analyzer, one insufflator, one dining table, two ultrasonic nebulizers, one bag sealer, and one portable X-rays unit. Out of 30 units analyzed, 23 (77%) obtained the expected result: seven for donation, eight for repair, two for reservoir and six for disposal. The remaining seven medical unit analysis did not match the expected result. A possible explanation for this result is shown in Table 1. It took from 3 to 5 min to fill in the technical description of the equipment when data was available.

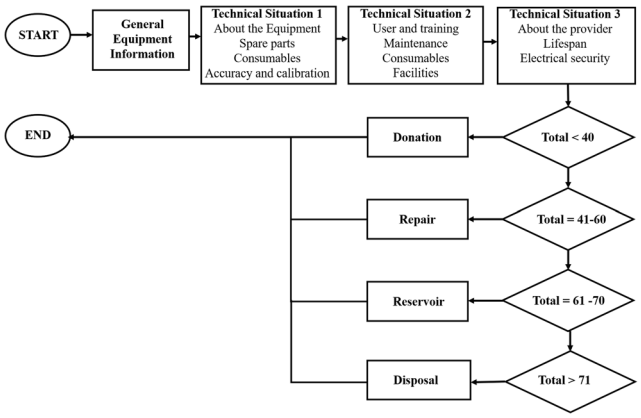

Fig. 1 Structure of the computer program. Built with Click Charts by NCH Software®

Table 1 Results expected and obtained for 7 medical units. The obtained result did not match the expert's opinion for these medical devices.

Medical device	Obtained result	Intended result	Justification
Infusion pump	Reserve	Disposal	Old and discontinued model
Coagulation analyzer	Reserve	Disposal	Cost of spare parts> cost of the equipment
Insufflator	Donation	Repair	No maintenance history
Dining table	Donation	Repair	Missing key piece
Ultrasonic nebulizer	Reserve	Disposal	There is no similar equipment in the hospital. It is not useful for spare parts
Bag sealer	Repair	Reserve	Expensive spare parts
Portable X-rays unit	Disposal	Reserve	Works, the pieces serve as spare parts in an identical model in operation

4 Discussion

We built a computer assistant program for safe and adequate medical device decommission. The program seeks to support hospital IT during the disposal process. Namely, the program helps determine if the technology should be donated, be repaired, should serve as a reservoir of spare parts, or be removed permanently. In order to generate a proper recommendation, user (i.e. hospital IT technicians) must enter explicit technical and functional equipment data. Then, the resulting display will show the safest and most cost-effective option for the user. From 30 units evaluated, 23 obtained the intended result, thereby suggesting that our assistant program could be tested in a real scenario (public secondary and tertiary care hospitals). However, results that compromise user's safety (donation and repair) must be adjusted to increase the program's effectiveness to 100%, this was evident in two out of seven medical devices in which the expert determined the units should be repaired, while APAD suggested Donation. Finally, we recommend using APAD as a backup tool to make the most convenient and safe decision in terms of medical device destination following disposal, and not as the sole tool regarding this stage of the MCMD.

5 Conclusion

Even though the APAD has given satisfactory results when tested on operating technology in a closed and controlled environment, it has not matched the opinion of experts in all cases (77% success). Likewise, it is necessary to determine if score adjustments in categories Donation and Repair will affect the outcome of the medical units already tested. The display of these results is strongly implicated with user's safety. In the future, we would like to suggest health institutes to rely on our assistant tool in Departments coordinating and managing medical technology. Similarly, our program could be used in Biomedical Engineering and Clinical Engineering Departments, to provide a backup opinion on the safest and most cost-effective equipment disposal alternatives. We expect that a prolonged use of the assistant program will promote successful donations of medical equipment, considering needs of both, the donor and the recipient.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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