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Use Of Criticality Criteria For Maintenance Of Medical Ventilators In Crisis Context

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In health crisis, the availability of medical equipment is not guaranteed. Devices in hospitals are becoming more and more complex and harder to manage and maintain, especially with the huge investment they require and the strict standards they must meet. Providing a sufficient number of reliable equipment in public health emergencies (PHE) is a global challenge for most of the health centers, to guarantee the safety of the patient. (PHE) are defined as "crises that adversely impact the public health system and its protective infrastructure (Frederick, 2019).

Hospitals are considered a critical and sensitive environment where this equipment might perform under severe conditions and emergencies and are required to be available in their most efficient state. Other factors must be considered to improve the hospital service level, gain accreditation and to remain financially safe.

Objectives

This research aims at the development of a generic multicriteria decision model for medical equipment maintenance during a crisis, based on different criteria found in literature and suggested by the assisting hospital. This work focuses on presenting the crisis factor and more specifically on the criticality criterion that would help identify the optimal maintenance policy and management strategy for medical ventilators especially in a crisis context.

Methodology

The decision aid method that is used is the ELECTRE methodology (Greco, 2016).
The proposed model can be summarized in the following steps:

- identify the asset management alternatives;
- identify all the efficient criteria and sub-criteria for criticality assessment of devices;
- determine weighting values for all criteria and sub-criteria;
- set up grades and determine intensities for each criterion;
- evaluate alternatives with respect to each criterion and assign grades and scores;
- identify the appropriate alternative.

The philosophy behind the suggested alternatives is to be able to identify the maintenance strategy that would allow the hospital to manage the ventilators replacement policy. The replacement time is usually shorter than the lifespan of the device (Waleed, 2020) but managing the V ventilators in stock should be optimized not to end up with lack of well-maintained reliable equipment or excess of expensive new ones. The suggested strategy would be to keep the N better ranked devices according to the model. The number N is concluded by analyzing the hospital data to estimate the average number of devices required in normal conditions. The used ventilators that are in a reliable condition and technologically up to date, will be stocked and maintained to be able to afford C devices for crisis use. Devices that are in technological obsolescence and whose spare parts can no more be found have to be replaced (Cheng, 2004). The units that are in poor condition (age close to the lifespan, hours of use) and require excessive maintenance (cost and time of maintenance) are candidates for removal. Other used ventilators that are in a reliable condition would be donated to health facilities with small budgets. Other used equipment will be stocked for spare parts use. For maintenance management, devices with higher criticality would be assigned to different actions such as systematic maintenance, user training, shorter inspection intervals, regular testing... And lower criticality devices would be maintained with the usual preventive maintenance actions or corrective ones.

The first step in the decision making is defining the criteria and sub-criteria, followed by calculating the weight and intensities of each criterion.

The selected criteria found in literature and suggested by and the CHwapi (Hospital Center of Wallonia-Picardie, Belgium) are part of 6 criteria families:

- the patient's safety;
- the cost ((Guzzo, 2020) maintenance cost, the acquisition of a new device cost…);
- users and medical staff-related criteria (user friendliness (Pinho, 2023) …);
- technical criteria (the criticality of the devices (Taghipour, 2011), number and frequency of failures...);
- environmental sustainability;
- crisis related criteria (increased mortality rate, treatment delays and complications, supply chain disruption, staff burnout, perceived time pressure, value of possible financial loss (Robert S.,1980), response readiness or resilience factors).

These include multiple sub-criteria such as the maintenance cost, the acquisition of a new device cost, the criticality of the devices, the number and frequency of failures, the required expertise, the user-friendliness, the reliability in emergencies (Zamzam, 2021) and the environmental sustainability.

Most of the authors have prioritized the safety of the patient basing their analysis on a risk-based method that classifies equipment according to their criticality and through favoring to guarantee an insured service and patients' safety than saving the cost of maintenance or new equipment. The Emergency Care Research Institute (ECRI) recommended using risk as the primary criteria for deciding the right planned maintenance plan (Jamshidi, 2014).

This ranking contributes to the way criteria's weights should be distributed in the decision model to deliver the most optimal result that not only should respond to the different factors set by the health care system and the CHwapi, but also be in the favor to patient's safety and comfort, the hospital staff and budget, the maintenance management and to the environment.

Results

The results of this methodology allow selecting the optimal maintenance and investment policy with respect to the identified criteria. A sensitivity analysis allows fine tuning of the decision process, to check the stability of the MCDA recommendations, and to help improve hospital performance in the context of a crisis.

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