Multi-Stakeholder Decision Making for Medical Equipment Management and Crisis Resilience

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During a crisis, decision-making becomes a critical process with several crisis related limitations. The only strategy to survive a crisis in any domain, is by preparedness and resilience planning. Crisis resilience is the ability to prevent or adapt to conditions caused by external or sometimes internal factors that disrupt the normal flow of work. This translates the preventive maintenance approach for example, where maintenance is implemented before the failure to avoid major breakdowns. In healthcare, this aspect gets even more critical considering that a major health crisis can put patients' health at risk, expose them to health complications, injuries or even death. Instant measures are not recommended in case of a crisis: equipment or staff may not be available, decision-making process and solution implementation face time limitation and potential risk outcomes outweigh its benefits.

That is why it is essential to define an equipment management plan by identifying the convenient replacement and maintenance strategy for medical equipment in health facilities, especially critical and life-sustaining devices. This strategy should ensure the availability of equipment during normal and crisis situations, balancing clinical effectiveness, financial sustainability and other operational factors that affect the decision-making process and the workflow in a hospital environment.

While traditional medical equipment management has focused on regulatory and standards compliance, manufacturer recommendation-based replacements, and cost optimization, this research adopts a multi-criteria framework consistent with industry 5.0 standards. This approach combines human-centric decision-making, multi-criteria methodology and resilience planning, particularly for critical medical equipment in healthcare facilities where failures of assets have a direct impact on patient outcomes and safety implications.

edical equipment management is not only technical or cost effective. Our approach involves criteria that recognize the human role and takes into consideration clinical staff familiarity with the equipment, the training burden on technical and medical staff, the easiness of maintenance and handling of equipment and general staff satisfaction. This contributes in an effective maintenance and replacement strategy planning: A clear and well-defined strategy responds to the staff's needs, creates clear work schedules, reduces pressure on maintenance department and clinical personnel by guaranteeing the availability of efficient equipment that does not endanger the patient and thus the staff's wellbeing.

To be able to balance cost effectiveness, availability of equipment, staff satisfaction, technological obsolescence, and other operational factors in decision-making, we suggest the use of Multi-Criteria Decision Analysis methods (MCDA) to be able to select the convenient decision alternative for equipment replacement and maintenance. MCDA is a tool set to help evaluate and prioritize multiple criteria to systematically compare different decision alternatives.

The use of MCDA techniques in healthcare related decisions and equipment management has been focusing on issues like prioritization of equipment for maintenance [1-3]; prioritizing for

equipment replacement [4-6]; classifying spare parts and optimizing inventory management [7]; and selection of maintenance strategy [8].

The purpose of this research is to generate a decision support system for medical equipment management to help decision makers select the parameters for an investment and maintenance strategy for critical medical equipment: case of ICU ventilators. This includes the selection and evaluation of the critical criteria for the decision, the evaluation and ranking of decision alternatives and presenting a decision support system for the multi-criteria process.

The Analytic Hierarchy Process (AHP) is chosen for pairwise comparison of criteria: patient safety; cost of ownership; staff satisfaction; sensitivity to obsolescence and easiness of procurement and logistics, and decision alternatives ranking regarding the fleet size and the age of replacement.

The results of this methodology allowed the selection of the optimal replacement and maintenance strategy for ICU ventilators, based on the age of replacement and the total number of equipment which affects the maintenance operations and cost and the number of equipment available thus the resilience to a healthcare crisis.

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