Chapter 2
Optimization of Maintenance in Critical Equipment in Neonatology

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ABSTRACT

Maintenance decisions by medical staff play an essential role in achieving availability, quality and safety in care services provided. This has, in turn, an effect on the quality of care perceived by patients. Nonetheless, despite its importance, there is a serious deficiency in models facilitating optimization of maintenance decisions in critical care equipment. This chapter shows a decision support system (DSS) for choosing the best combination of maintenance policies, together with other actions for improvement, such as the increase in the number of back-up devices used in the assisted breathing unit in the Neonatology Service of a hospital. This DSS is combined with an innovative form of continuous time Markov chains, and the multicriteria Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH). The result is a ranking of the various maintenance alternatives to be applied. Finally, the real implications for availability and quality of care of applying the best solution are described.

INTRODUCTION

Maintenance decisions by medical staff play an essential role in achieving availability, quality and safety in care services. This has, in turn, an effect on the quality of care perceived by patients. Nonetheless, despite its importance, there is a serious deficiency in models facilitating optimization of maintenance decisions in health care organizations. There is, however, literature analysing the choice of maintenance policies in manufacturing, transport, processing, energy companies, etc., which shows how little importance has been attached to these logistical processes in hospitals.

DOI: 10.4018/978-1-5225-2515-8.ch002

Also, most of the literature dealing with the choice of the most suitable maintenance policy to be used in industrial settings does not consider the fact that in common practice organizations apply a combination of maintenance policies rather than just one.

This chapter shows a Decision Support System (DSS) for choosing the best combination of maintenance policies, together with other actions for improvement, such as an increase in the number of back-up devices used, in the assisted breathing unit in the Neonatology Service of a hospital. This DSS uses an innovative combination of continuous time Markov chains and the multi-criteria Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) approach. This involved using judgements given by a decision group made up of those in charge of different areas of the hospital.

The result is a ranking of the various maintenance alternatives to be applied. Finally, the real implications for availability and quality of care of applying the best solution are described. This is the first study aimed at optimizing decisions about the maintenance policies to be used in such critical systems as the assisted breathing unit in a Neonatology Service.

This chapter is structured as follows: Firstly, there is a review of the literature on maintenance policy selection. Then the DSS developed for the optimization of maintenance in the assisted breathing unit in a Neonatology Service is described; this includes the application of Markov chains to this system, as well as the construction of the multi-criteria model using the MACBETH approach. It also shows the full classification of the alternatives obtained as a result, and the sensitivity analysis of the model. Finally future lines of research, acknowledgements and conclusions are presented.

BACKGROUND

Although there are many mathematical models and optimization techniques applied to maintenance in the literature, they mostly optimize a single maintenance policy, and are mathematically so complex that to put them into practice in organizations is extremely difficult.

Choosing a maintenance policy in an organization is a complex decision, as it is necessary to analyse technical aspects, related to machinery and facilities, at the same time as organizational and strategic matters. This decision affects availability of machinery and facilities, plant and staff safety, quality of the product or service, and maintenance costs.

It is therefore necessary to take into account a variety of criteria, both quantitative and qualitative, when taking this decision, which is why the use of Multi-Criteria Decision Analysis (MCDA) techniques is justified (Carnero, 2014). In fact, Almeida and Bohoris (1995) and Martorell et al. (2005) underlined the benefits of using multi-criteria techniques in the field of maintenance, especially when reliability, maintainability, availability and safety are involved in the decision.

Despite its importance to organizations, there are few studies analysing maintenance policies (Wang, Chu, & Wu, 2007). Among the literature analysing choice of maintenance policies with multi-criteria techniques, Bevilacqua and Braglia (2000) used Analytic Hierarchy Process (AHP) to choose the best maintenance policy in an Integrated Gasification and Combined Cycle plant, is particularly worth of note. Azaiez (2002) uses multi-attribute utility theory to choose an optimal replacement policy. Al-Najjar and Alsyouf (2003) applied a fuzzy multi-criteria decision-making methodology to find that Total Quality Maintenance using vibration analysis is the best maintenance policy to use in a paper mill. Emblems-