Hospital-Based Expert Model for Health Technology Procurement Planning in Hospitals.

R. Miniati, G. Cecconi, F. Frosini, F. Dori, J. Regolini, E. Iadanza and G. Biffi Gentili

Abstract— **Although in the last years technology innovation in healthcare brought big improvements in care level and patient quality of life, hospital complexity and management cost became higher.**

For this reason, necessity of planning for medical equipment procurement within hospitals is getting more and more important in order to sustainable provide appropriate technology for both routine activity and innovative procedures.

In order to support hospital decision makers for technology procurement planning, an expert model was designed as reported in the following paper. It combines the most widely used approaches for technology evaluation by taking into consideration Health Technology Assessment (HTA) and Medical Equipment Replacement Model (MERM). The designing phases include a first definition of prioritization algorithms, then the weighting process through experts' interviews and a final step for the model validation that included both statistical testing and comparison with real decisions.

In conclusion, the designed model was able to provide a semi-automated tool that through the use of multidisciplinary information is able to prioritize different requests of technology acquisition in hospitals. Validation outcomes improved the model accuracy and created different "user profiles" according to the specific needs of decision makers.

I. Introduction

Technology replacement and innovation-based acquisition are the main aspects to take into consideration by hospital decision makers for guaranteeing proper and safe medical care to patients. Health technology procurement follows the needs of medical staff for to have adequate and appropriate equipment in order to perform routine activity and possibility of improving, by new technology procurement, the whole medical process of care and treatment in terms of clinical outcomes, technical performances and economic sustainability.

In addition, the organizational complexity of hospital areas besides the increasing number of different technologies available on market, make the procurement planning more complicated. Hence, the paper aims to design an expert model for supporting decision maker in defining the purchasing planning by estimating different priorities between innovation and replacement. The paper and the final report are intended to help decision makers to decide what to purchase and/or replace.

II. Methodology

The proposed methodology included 3 main phases: first, the analysis of the state of art of technological replacement modeling and health technology assessment; secondly, the design and development of the expert model; and as last part, the elaboration of reporting system and the model validation.

A. *MERM and HTA models*

Some of the main used decision support systems for technology procurement are the Medical Equipment Replacement Models (MERM). They provide purchasing priorities according to technology replacement need of obsolete devices through the estimation of specific indexes. They have rapid and semi-automated response but they are based on technical parameters only (e.g. age, failure rate, complexity, etc.) and just provides a first preliminary assessment [1, 2], see figure 1.

On the other hand, Health Technology Assessment (HTA) and Horizon Scanning (HS) techniques provide with more detailed analysis by taking into consideration both

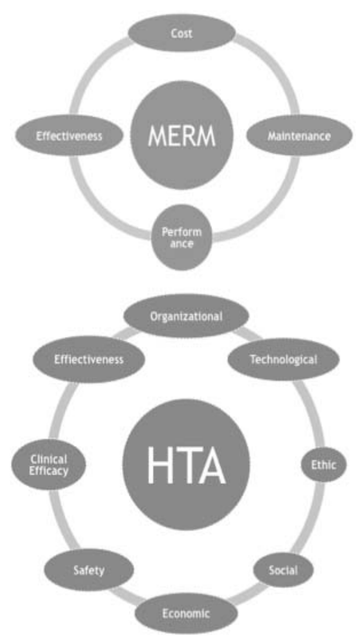

Figure 1. MERM and HTA models.

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R. Miniati is with the Information Engineering Department at the University of Florence, Via Santa Marta 3, Florence, 50139 ITALY (phone: +393286017001; e-mail: roberto.miniati@unifi.it).

G. Cecconi, F. Frosini, F. Dori, J. Regolini, E. Iadanza and G. Biffi Gentili are with the Information Engineering Department at the University of Florence, Via Santa Marta 3, Florence, 50139 ITALY.
(e-mail: giulio.cecconi@unifi.it, francesco.frosini@unifi.it, fabrizio.dori@unifi.it, jacopo.regolini@alice.it, ernesto.iadanza@unifi.it, guido.biffigentili@unifi.it).

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technology replacement and technology innovation [3-5] as they evaluate multidisciplinary aspects such as clinical, social, legal, safety, economic and organizational impact, see figure 1. With respect to MERMs, HTA or HS reports production may result in a very long time.

Hence, the main designing requirements for the expert model can be summarized as a proper compromise between response rapidity (use of automated system) and results reliability (use of multidisciplinary indicators). Moreover, as suggested by scientific literature [6, 7, 8, 9], a further designing specification is the development of a priority-based model in order to support decision makers for comparative estimations amongst technology needs.

B. *Expert model design*

The model data can be divided into two main areas: one including the intrinsic characteristics of the technology and another one linked to its context of use. In order to properly cover both areas, ten preliminary indices were defined as a combination of weighted factors:

1. Strategic importance;
2. Cost;
3. Economic impact;
4. Functionality;
5. Use-related Risk;
6. Technological obsolescence;
7. Technology distribution within the hospital department;
8. Hospital area criticality;
9. Replacement priority;
10. Research activity priority.

The weights were defined by a panel of hospital experts belonging to different fields of competence: technology, clinical and economic. Two final outputs of the model were defined for each technological request of purchasing: Evaluation Priority Index (EPI) and the Acquisition Priority Index (API).

Evaluation Priority Index (EPI) – As the paper focuses on a general expert model for rapid support to decision makers, it is important to define which purchasing requests need further analysis (HS or HTA reports) and which one do not. As reported in (1), the main factors composing EPI are the impact of technology on hospital strategy (I_S), on budget (I_C) and on technical appropriateness (I_F). The coefficients α, β and γ represent the specific importance given to each factor (α=1, β=0.55, and γ=0.45).

$$EPI = \left(\alpha \times I_S + \beta \times I_C + \gamma \times I_F\right) \div \left(\alpha + \beta + \gamma\right) \qquad (1)$$

Acquisition Priority Index (API) – API estimation is more complicated than EPI as it includes many more factors that may influence the priority of acquiring a specific technology. As reported in (2), API directly depends on technical appropriateness (I_{PU}) and the context of use (I_{PC}), which further depends on the number (inverse proportionality to I_{PC}) and the age (direct proportionality to I_{PC}) of the already existing similar technologies to the requested one, and the clinical criticality of the medical area (direct proportionality to I_{PC}). The coefficients α, β represent the specific importance given to each factor (α=1, β=0.55, and γ=0.4).

Finally, (2a) and (2b) are special cases for API estimation, where (2a) represents the case of real need of technology replacement need (RP=0.8) while (2b) specifies a technology essential for research purposes as well (RA=0.6).

$$API = \begin{cases} \left(\alpha \times I_{PU} + \beta \times I_{PC}\right) \div \left(\alpha + \beta\right) & (2) \\ RP + 0.1 \times \left(\alpha \times I_{PU} + \beta \times I_{PC}\right) \div \left(\alpha + \beta\right) & (2a) \\ RA + 0.1 \times \left(\alpha \times I_{PU} + \beta \times I_{PC}\right) \div \left(\alpha + \beta\right) & (2b) \end{cases}$$

C. *Reporting development and model validation*

The main goal of proper reports is summarizing to decision makers the whole problematic with few but useful information in a usable format. The report designed in this work is structured in four parts: the first one contains the main summary of technology requests including time reference, number of requests per hospital department and total costs (for both hospital and specific department); the second part contains the list ordered by EPI with special attention to the sub-indices (I_S, I_C and I_F); the third one presents the list of technology acquisition ordered by API; the last part includes additional data.

In order to assess the reliability and accuracy of the model two different types of validation were carried out, one scientific including statistical analysis valuating robustness and sensitivity; and one oriented to users' decision and experience by comparing, through simulation data, the outputs of the model with real decisions.

III. Results

The model was applied to 48 simulated technology requests of purchasing coming from 10 different hospital departments. As reported in figure 2, the "accuracy" of the model for technology priority estimation, compared to "real" decisions, passed from a percentage of 68% of the initial model, to 69.5% for the model including the special case described in (2a) and (2b) and to a final 72.5% for the model modified by the validation.

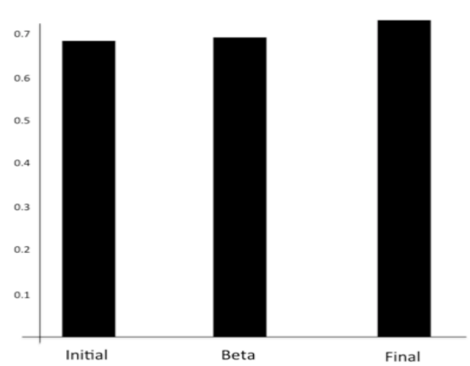

Figure 2. Expert model accuracy according the different designing steps.

The validation results for EPI are shown in figure 3. Modeling feedback from users' validation mainly regarded the new weighting balance of EPI sub-factors: Costs (I_C) and Hospital Strategy (I_S) resulted the most important factors while Functional Appropriateness (I_F) decreased in importance. Hospital clinical strategy is the main influencing factor for EPI.

For API validation outcomes, Functional Appropriateness, Cost and Technology Destination of Use are the most influencing factors while the context of use (number and age of similar devices, clinical importance of the area) decreased their importance to API estimation, see figure 4.

Last results included the creation of different default profiles of the model, according to specific needs of the decision maker, by specifically varying the weights of the general model. According to precise and temporary business needs, the model could comply the requirement of enhancing certain aspects than others. All these profiles are available for both API and EPI outputs and embraces the following users: Standard, Budget-oriented, Innovation-oriented, Routine-activity-oriented.

IV. Conclusions

The expert model presented in this paper represents an innovative solution within the scientific literature on health technology procurement planning, as the expert model was not developed for substituting usual HTA/HS reports but for providing a first prioritization of hospital requests for technology purchasing. Hence, with respect to the HTA/HS models, although the model cover many multidisciplinary aspects (clinical, economic, technological) it is more flexible and lower time-consuming.

The results showed how the model is highly reliable, with ability to discriminate hospital technology requests. Moreover, differently to MERMs, that stop at the calibration phase without any phase testing [10], the expert model was continuously tested and enhanced during all the designing process till reaching, for the final version, a 4% accuracy improvement.

The validation phase brought some useful modifications of the weighting combination amongst the sub-factors and created specific "user profiles" in order to allow decision makers to adapt the model to their specific needs.

Finally, future developments concern the complete automation of the system by using IT tools, and the development of specific section where budget constraints are evaluated.

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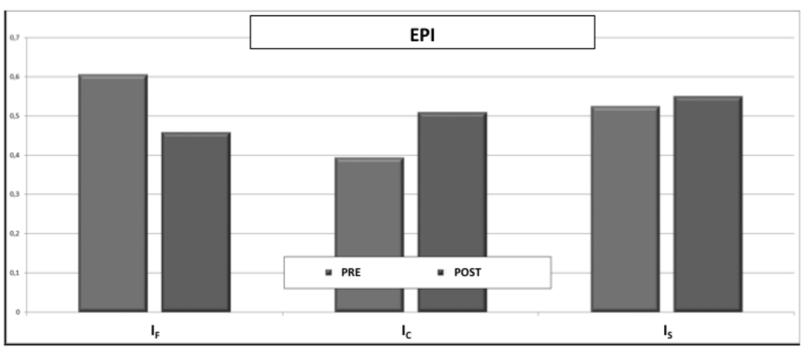

Figure 3. EPI pre- and post-validation weights.

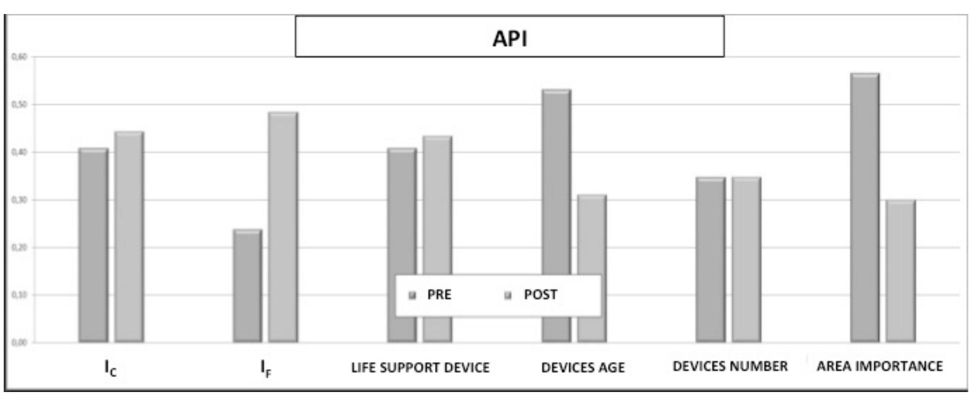

Figure 4. API pre- and post-validation weights

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