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The Use of a Mathematical Model in the Adoption of an Integrated EHR System

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Abstract and objective

The development of healthcare information systems is broadly considered a promising strategy to ensure, enhance and deliver of quality patient services, thus improving the healthcare economic sustainability [1]. However, their systematic evaluation needs to implement economic evaluation models that can help decision makers to determine a feasible and suitable analysis of the impact of an information system in the appropriate healthcare setting [2]. Aim of this paper is to define a mathematical model to provide an "ex–ante" measure of adequacy and significance in the adoption process of Electronic Healthcare Records (EHRs). In particular, the model establishes how different subjects (General Practitioners, GPs and patients) are involved in the testing process and how the resources provided can be invested to find out the most suitable intervention strategies.

Keywords

Mathematical model, Cost Benefit Analysis, Healthcare Information System, Electronic Health Record, Additive model.

Introduction

The use of mathematical modeling is often connected to issues and decisions rules of Cost Effectiveness Analysis, since it deals with the maximization of aggregate health effectiveness [3]. However, due to actual budget constraints, decision makers may not be able to fund the implementation of all healthcare programs with positive net benefits. Moreover, Regional Governments are called to "match" national directives with local issues and benefits evaluation strictly depends on the kind of results pursued. In our perspective, the problem may be viewed as a constrained optimization in which benefits have to be maximized with respect to the budget constraint, heading therefore toward Cost-Benefit Analysis (CBA) [4].

Methods

This paper introduces a CBA based additive model to measure both adequacy and significance of EHRs deployment, in order to: (i) address all the issues concerning the feasibility of the adoption process, along with its technical, political and organizational features; (ii) redesign if necessary an adoption and running plan better, aligned with the nurtured expectations. In this work the suitability of the mathematical model proposed is tested taking into account the LUMIR system [1], an EHR that helps healthcare professionals to exchange patients' information collected during each healthcare event. Main features of the model are: 1) each month an increasing number of GPs are enlisted in the adoption process (m_0 in the first month; $m_1 > m_0$ in the following); 2) each GP enrolls each month an increasing number of patients (p_0 in the first month; $p_1 > p_0$ in the second; $p_2 >> p_1$ in the following); 3) the maximum number of GPs (M_{med}) and patients per GP (P_{real}) are set considering the peculiarities of the healthcare setting (i.e. human resources) and determines three saturation points when: all GPs (n_{med}), all patients per GP (n_{sat}) and total patients (n_{last}) are enrolled; 4) the adoption process is limited in time (n_{sup}); 5) costs are assessed considering the available budget and the technical support; benefits are assessed by highlighting the number of GP/patients encounters during the whole adoption process. Based on these features, main aim of the model is to maximize the cost benefits ratio (*objective function*), figure 1.

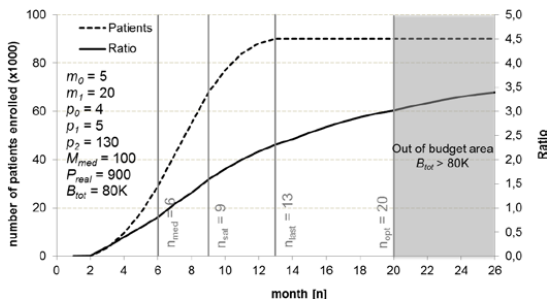

Figure 1 - Trend of ratio and patients enrolled per month

Results

The optimal solution takes into account the resources deployed to run the system, leading to the following considerations: 1) the more patients are enrolled, the higher is the cost-benefits ratio; 2) the number of GPs to be enrolled strictly depends on the costs of technical and administrative activities; 3) the lifespan of the process is mainly related to the availability of the budget that can be allocated to test the system – an extra budget allows in fact the adoption process to be extended, as made evident in Figure 1, where the objective function is a monotonically increasing function.

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