Applying the System Dynamics Approach in Evaluating Clinical Risk Management Policies in Three Healthcare Companies

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Abstract

This paper explores and extends research on the role of system dynamics methodology as a powerful approach to clinical risk management (CRM). We report our preliminary findings on CRM in three healthcare organizations. We use system dynamics methodology for exploring the multi-dimensional facets of hospitals' complex operations management systems. We address theoretical scholarly matters focusing on the depiction of managerial insights to gain more understanding of CRM. We investigate the impacts of CRM implementation on the hospital financial performance along with other indicators. We provide a summary of our findings and their empirical and theoretical implications and contributions.

Key words: clinical risk management, healthcare systems, system dynamics, hospitals' financial performance indicators, human resource management

1. Introduction

The need for exploring and understanding Clinical Risk Management (CRM) is important in that hospitals are high-risk organizations with multi-faceted structural dynamics, elaborate internal operations, varied external environments, fluid organizational cultures, and multiple stakeholders with numerous interests and expectations. An increased level of patient safety awareness came to light due to wide media coverage of clinical errors. The high number of exorbitant compensation claims and the steep rise of insurance costs have recently forced healthcare companies to seriously consider CRM.

We focus our efforts on drawing managerial insights for better understanding of human behavior on the complex processes of CRM implementation. Our findings are based on data collected from a sample of 204 clinical and managerial staff members of doctors, nurses, and clinical risk managers in three healthcare companies in Italy.

The main objective of this paper is to present our research preliminary results along with their implications. This will be accomplished by describing a research project aimed at building a management flight simulator, based on the system dynamics (SD) methodology. Our goal is to, ultimately, support healthcare companies' management in experimenting with different CRM policies by monitoring their potential effect on the financial and non-financial performance indicators. The management flight simulator is intended to help healthcare managers in designing CRM policies to guarantee both a satisfying level of patient safety and a sustainable growth.

Risks associated with patient care cannot be totally eliminated; therefore, CRM plays a vital role in enabling hospitals to enhance patient safety (Vincent, 2006). It is important to note that Risk Management (RM) generally encompasses political, legal, and business environment risks (Young et al., 2002). Additionally, CRM is a specific form of RM focusing on clinical processes directly and indirectly related to the patient.

It follows that CRM can be defined as all structures, processes, instruments, and activities which enable hospital staff to identify, analyze, contain, and manage risks while providing clinical treatments and patient care (Walshe, 2001). Naturally, there are other aspects of hospital governance that influence patient safety. They include financial or infrastructural risk management, or health policy issues such as hospitals accreditation matters. The core point is that systematic CRM integrates both a proactive and reactive approaches, and frames the hospital as a system, instead of focusing on individuals and their potential for committing errors (Corrigan et al.; 2001, Misson, 2001, Reason, 2000). This is why hospitals are an ideal setting for understanding and implementing the system dynamics paradigm.

It is important to note that CRM practices, such as the introduction of guidelines and protocols, patient involvement, etc., do not take into account expenditures and their influence on the employees' behavior. Indeed, such practices, if not properly managed, can give rise to medics and paramedics' work overload burnout, which would inevitably increase the probability of errors.

In other words, improving hospitals' risk profile, although ethically incumbent, often requires significant investments. Therefore, some healthcare companies opt not to invest in CRM due to its high cost, and the added complexity of its operating procedures. Factored in their decisions are also the difficulties experienced in appraising the outcome benefits from investments aimed at reducing clinical risks.

The relevance of human factors in the occurrence of errors and effects of CRM policies on the management of personnel also dictate the adoption of a human resource management perspective, that may help healthcare managers in evaluating the role of staff behaviors in the success of CRM policies and, therefore, in designing CRM interventions that take into consideration the workforce attitudes, motivations, biases, etc.

Indeed, improvements of clinical risk profile often allow hospitals to realize important savings on insurance costs. It can also boost institutions' image and increase their competitive advantage. For this reason, it is essential to adopt a systemic and multi-dimensional (Berg, 2010) approach that allows healthcare companies to properly evaluate CRM policies effects on organizations' performance, in the short, and medium long term.

2. Literature Review and Theoretical Framework

This section provides literature review on two interrelated elements: the CRM process and the system dynamics perspective. Recent work (Briner, 2010) suggests that despite the multitude of initiatives, programs, systems, and tools that can be viewed as elements of CRM there is a lack of knowledge concerning their implementation in hospitals.

Hospitals have always been concerned with enhancing patient safety. However, it is noteworthy that this issue became a core consideration since the publication of the Institute of Medicine reports “To Err Is Human, 1999”, and “Crossing The Quality Chasm, 2001”. Afterwards, a widespread application of systematic CRM has taken place (Vincent, 2006; Misson, 2001; Chiozza et al., 2006). At the organizational level, many RM tools have been adapted from other high-risk industries such as aviation. Incident reporting is also gaining increased acceptance among hospitals and is viewed as a possible method for promoting learning from errors (Barach et al., 2000; Leape, 2002; Secker et al., 2001). In addition, several patient safety initiatives have been launched at both the national and internal levels (Joint Commission, 2008).

2.1. Clinical Risk Management

Research by Young et al. 2002 and Misson (2001) shows that the following dimensions represent three major variables of risk management:

- Risks to Patients: Following medical ethical standards is key to minimizing risks and maintaining patient safety. This is in addition to compliance with statutory regulation; learning from complaints; and also ensuring regular systems reviews and questioning - by critical event audit.
- Risks to Practitioners: Ensuring that clinicians are immunized against infectious diseases, work in a safe environment, and are helped to stay current as essential parts of quality assurance.
- Risks to the Organization: Poor quality is a threat to any organization. In addition to reducing risks to patients and staff, organizations need to ensure high quality employment practices, by introducing measures to review individual and team performance, and introducing well-designed policies on public involvement.

CRM is an approach for improving the quality and safe delivery of health care. This can be accomplished by placing special emphasis on identifying conditions that put patients at risk, and by establishing mechanisms to minimize or prevent these risks.

This point to the fact that CRM systems are essentially dedicated to delivering risk reduction strategies. It is also important to emphasize that CRM goals include: identification of risks, prevention of harm, injury and loss, and controlling systems and processes with the deliberate goal of eliminating or reducing severity of damage.

It is important to note that healthcare companies adopt strategies to identify potential causes of active or latent errors. They also implement organizational procedures aimed at eliminating the causes of the identified errors. Therefore, the adoption of the CRM approach in this research project is aimed at initiating a cultural change oriented toward increasing patient safety in the companies participating in the project (McFadden et al., 2009).

Vincent et al. (1998) proposed a general framework of factors influencing clinical practice and contributing to medical adverse events (Table. 1).

Table 1. Framework of Factors Influencing Clinical Practice and Contributing to Adverse Events (Vincent et al., 1998)

Framework	**Contributory Factors**	**Examples of Problems That Contribute to Errors**
Institutional	Regulatory context Medico-legal environment National Health Service Executive	Insufficient priority given by regulators to safety issues; Legal pressures against open discussion, preventing the opportunity to learn from adverse events
Organization and management	Financial resources and constraints Policy standards and goals Safety culture and priorities	Lack of awareness of safety issues on the part of senior management; Policies leading to inadequate staffing levels
Work environment	Staffing levels and mix of skills Patterns in workload and shift Design, availability, and maintenance of equipment Administrative and managerial support	Heavy workloads, leading to fatigue; Limited access to essential equipment; Inadequate administrative support, leading to reduced time with patients
Team	Verbal communication Written communication Supervision and willingness to seek help Team leadership	Poor supervision of junior staff; Poor communication among different professions; Unwillingness of junior staff to seek assistance
Individual staff member	Knowledge and skills Motivation and attitude Physical and mental health	Lack of knowledge or experience; Long-term fatigue and stress
Task	Availability and use of protocols Availability and accuracy of test results	Unavailability of test results or delay in obtaining them; Lack of clear protocols and guidelines
Patient	Complexity and seriousness of condition Language and communication Personality and social factors	Distress; Language barriers between patients and caregivers

Although Vincent's general framework depicts the main factors contributing to clinical errors, the underlying approach is far from a root-cause analysis perspective for two reasons: First, the root-cause analysis hypothesizes that there is a single or at least a small number of root-causes, while clinical evidences demonstrate that errors are often a consequence of a wide array of factors. Second, despite the primary aim of the root-cause analysis is to find the real cause for errors, the main goal of a deeper analysis should be the identification of gaps in the system, where the approach is much more proactive and forward-looking. For these reasons, Vincent (2003) calls this deeper approach “systems analysis”. The research team found it requisite to model the hospital’s systems utilizing the system dynamics methodology to capture the complexity characterizing the environment where CRM policies and behavioral operations techniques have to be implemented.

It is important to note here that the three dimensions of risk management identified above are not intended to be captured by the study questionnaire (to be discussed below). Instead, they were intended to serve as part of the theoretical framework to simply help readers understand the landscape and the broader context of the research undertaken. This reinforces professional research conventions requiring that the literature review/theoretical framework to be much broader than the scope of the study questionnaire. In short, these three factors will not be further explored or captured by the questionnaire.

2.2 The System Dynamics Perspective

This is the second element of our theoretical framework. System dynamics is a methodology for understanding the behavior of complex systems over time. It deals with internal feedback loops, time delays, stocks, and flows that affect the behavior of the entire system. These elements help describe how even seemingly simple systems display baffling nonlinearity (Sterman, 2001; Repenning, 2001). System dynamics uses tools like causal mapping and simulation modeling (Bendoly et al., 2010). Traditional system dynamics models incorporate boundedly rational individuals’ decisions as well as heuristics and biases, and examine their impact in complex dynamic settings, where the results of individuals’ decisions change the future state of the system which, in turn, influences future decisions.

Research by Bendoly et al. 2010 demonstrates that there are two types of misperceptions of feedback: structure and dynamics. Misperceptions of feedback structure are caused by mental maps that have a poor representation of the complexity of the real system; for instance, a mental model that ignores important feedback processes in the system. Misperceptions of feedback dynamics are caused by inaccurate mental models of how the system behaves. In this case, a mental model that fails to capture the impact caused by accumulations will poorly infer their dynamics. Sterman’s work (1989) suggests that the misperception of feedback arises from people’s adoption of deficient dynamic mental models that guide decisions. These deficiencies include an event-based perspective, focusing on specific events instead of the system structure that generates them; an open loop view of causality where previous decisions lead to outcomes and do not change the current state; failure to understand the impact of delays and of accumulations by not separating cause and effect; and insensitivity to nonlinearities, which alter the structure and behavior of the system. The dangers of these misperceptions were very well articulated by (Bendoly et al. 2010). They suggest that these misconceptions cause decision making errors.

Despite the relative newness of the adoption of the system dynamics methodology in the CRM field, different examples of applications of the system dynamics approach to the healthcare sector have been reported in the literature (Dangerfield, 1999; Wolstenholme, 1999; Homer & Hirsch, 2006). These important contributions highlighted the numerous advantages of using system dynamics models to manage the complexity characterizing the healthcare sector.

3. Clinical risk management in the healthcare context

CRM has not often found *a real* application in three healthcare companies. Healthcare organizations limited their engagements to a formal implementation of the prescribed procedures without any substantial improvement in the patient safety culture. In fact, many initiatives were prompted by media campaigns about serious adverse events resulting from clinical errors. These initiatives were concluded immediately after the initial euphoria. National and regional institutions have managed the problem of medical malpractice by enacting mandatory rules and regulations that have required healthcare companies to participate into a data collection activity aimed at feeding a central error – monitoring system. However, the central error monitoring system did not allow for collecting reliable information about the so called "near miss" and "no harm" events. In addition, the internal clinical risk committees limited their activities to suggesting procedures that have not been implemented. Furthermore, in Italy, no relevant data are available about the occurrence of clinical errors, their main causes, the definition of performance indicators aimed at measuring the improvement in the management of the clinical risk (Trucco and Cavallin, 2006.

In short, it appears that incentives for healthcare companies to adopt CRM policies is simply lacking. Therefore, it is important for such companies to realize that improvements of their risk profile would not only allow them to obtain considerable savings on insurance costs, but would also enable them to enhance their image, reputation, and increase their competitive advantage. So far, very few companies have applied for or attained the accreditation from the Joint Commission International, the most prominent non-governmental and non- profit organization that certifies healthcare organizations if they meet a set of standard requirements designed to improve quality of care. From the above analysis, we can conclude that despite the numerous attempts of the national and regional governments to spread CRM practices, they remain quite limited. A real change in the patient safety culture can be realized only if the required investments to improve healthcare organizations' risk profile are economically feasible. However, in order to properly implement cost-benefit analyses, the healthcare companies' management should quantify short and medium-long term effects of CRM policies. Such policies may include a financial aspect like compensation costs, insurance premiums, revenues, and the non-financial variables including company image, customer satisfaction, personnel motivation.

4. An Assessment of the System Dynamics methodology application to CRM

Presently, in order to detect errors and assess their potential effects, clinical risk managers adopt monitoring tools, such as incident reporting, clinical audit, and methods of process analysis, such as the root-cause analysis and the hospital failure mode and effect criticality analysis. However, these methods are based on a linear analysis of the causal relationships characterizing the business processes. In particular, they do not take into account feedback structure underlying the net of causality connecting the variables of the different company sub-systems (Lee et al., 2009). Furthermore, these analyses are static (Cavallin et al., 2006), namely they ignore delays normally existing between the triggering of the cause and the occurrence of the related error and, consequently, they are not suitable to simulate future trends (Trcek, 2008).

Also, the present time clinical risk assessment methods are inadequate in helping healthcare organizations in setting safety targets and evaluating safety performance improvement on a quantitative basis (Trucco and Cavallin, 2006). Moreover, the root - cause analysis can also be misleading because it focuses only on identifying the root cause, but an adverse event usually does not have a single root cause (Trucco and Cavallin, 2006).

The limitations of the system dynamics methods discussed above may undermine the identification of the real company processes' criticalities. Similarly, the organizational practices implemented to reduce the clinical risk, such as the "only therapy sheet", the introduction of guidelines and protocols, the patient involvement, etc., often increase workload burnout, which inevitably augment the probability of errors. Therefore, it is necessary to adopt a multi-dimensional and systemic (Cook and Rasmussen, 2005) approach that allows hospitals to assess, according to a holistic perspective, the effects of CRM policies on the company performance.

5. Research Methodology

The study was carried out in three healthcare companies: (1) a private hospital (identified here as Hospital A), placed in a little town near to a big city (the capital of the Region), which serves a population of 30.000 people; (2) a private hospital (identified here as Hospital B), placed in the big city, which serves a population of about 700.000 people; (3) a public hospital (identified here as Hospital C), placed in a medium town 200 kilometers away from the big city, which serves a population of 120.000 people. Table 2 shows some macro-variables of these hospitals.

Table 2. Some macro-variables of the hospitals involved in the research.

Hospital	(A)	(B)	(C)
Location	Small Town (29.000)	Big Town (655.000)	Medium Town (77.000)
Type	Private	Private	Public
Beds	60 (Normal = 54; Day H. = 6)	94 (Normal = 85; Day H. = 9)	226 (Normal=187; Day H.=39)
Employees	62	163	517
Annual Budget (2010)	€ 4.122.422,00	€ 12.922.323,00	€ 19.980.582,00
Annual Budget (2009)	€ 4.340.370,00	€ 12.650.595,00	€ 21.127.943,00
Average Income per Patient (2010)	€ 4.330,28 (2010)	€ 2.127,83	€ 2.510,75
Average Income per Patient (2009)	€ 5.136,53 (2009)	€ 2.184,90	€ 2.511,34

In-patients (2010)	952 (M = 665; S = 287)	6073 (M =1115; S =4958)	7958 (M = 6276; S = 1682)
In-patients (2009)	845 (M = 613; S = 232)	5790 (M =991; S =4799)	8413 (M = 6906; S = 1507)
ER	NO	NO	YES
Clinical Risk Committee	YES	YES	YES
Clinical Risk Manager	YES	YES	YES
Hospital Surgery Specialties	Orthopedics (surgery) and Cardiology (pacemaker)	Midwifery (surgery), Urology (surgery) and Cardiology (pacemaker)	All Specialties

As shown in Table 2, all hospitals have a clinical risk committee and a clinical risk manager. According to the National Healthcare System, the Hospital "C" is not an autonomous hospital from a managerial perspective, but it is part of a regional healthcare District placed in a medium town in the middle of the region. The General Manager of the Hospital "C" is the head of the regional Healthcare District, which groups two main hospitals and other medical and surgical services.

5.1 Subjects

To collect data about the adopted CRM procedures, and the dynamics of clinical errors and formal complaints at each of the three hospitals we interviewed: The General Manager, the Medical Director and the Clinical Risk Manager. Furthermore, a questionnaire was administered to the hospital personnel. To qualify for inclusion, staff members had to have worked in the hospital for a minimum of one month prior to administering the questionnaire. As a rule-of-thumb, we invited all personnel within a clinical area to participate. - that influence or are influenced by the "working environment", e.g., Attending/Staff Physicians, Resident Physicians, Registered Nurses, Charge Nurses, Pharmacists, Respiratory Therapists, and Technicians; responses were voluntary. Table 3 shows the main sample demographic characteristics.

Table 3. The sample demographics characteristics.

	HOSPITALS					
	Hospital A		Hospital B		Hospital C	
	N	%	N	%	N	%
Response Rate	35	56%	41	25	128	25
Job Profile:						
· Doctor	11	31,43%	13	31,71%	42	32,81%
· Nurse	10	28,57%	18	43,90%	51	39,84%
· Staff	11	31,43%	10	24,39%	10	7,81%
missing data	3	8,57%	0	0,00%	25	19,53%

Sex:						
· Male	23	65,71%	14	34,15%	39	30,47%
· Female	7	20,00%	26	63,41%	31	24,22%
missing data	5	14,29%	1	2,44%	58	45,31%

Data were collected in agreement with units' leaders. To keep track, the questionnaires were numbered, respondents' names were not recorded, and there were no name-and-number lists. The subjects were asked about their role -doctor, nurse, staff- and gender. No personal information was collected to avoid fear of respondents' identification. As shown in Table 3, the total sample size was 204; and the response rate was: 56% in Hospital A; 25% in Hospital B; and 25% in Hospital C respectively. The response rates per job profiles and gender are presented in the table.

5.2 Methods, data collection, and research instruments

5.2.1 Designing the causal loop diagram (CLD) by group model building (GMB) sessions

Following Vennix et al. (1992), three main tasks were performed by modelers before the intervention: elicitation of information, exploring courses of action or convergent tasks, and evaluation. Once group members agreed about the procedures, the first phase started and adaptation of the model was performed. During this phase, interviews, cognitive maps, nominal group techniques, and workbooks were the main instruments used. During the convergent tasks phase, the subjects were called to choose between alternative problems elaboration, structural model and different policies. This phase was characterized by intensive of face- to- face discussion techniques. During the evaluation phase, the group discussed and agreed on the different issues. As a result of the intervention, not only choices were assumed, but also changes involving the mental models were pursued. Research by (Vennix et al., 1997) indicated that GMB has been viewed as a method to facilitate a stimulating learning process. The main output of the GMB sessions was the CLD, a document that describes the causal relationship between the key-variables of the three healthcare companies in this study.

5.2.2 Exploring the CRM procedures in the hospital

To explore the CRM procedures adopted by the three hospitals, we asked the clinical risk managers to refer to the official document describing the CRM company plan (Audit Plan). The document defines the responsibilities, activities, and records to be made to ensure an effective prevention of clinical risk caused by medical activities and the management of adverse events. An Audit Plan had to be developed in accordance with the national laws. Furthermore, the flow-charts for each hospital were analyzed, the overall clinical processes were activated by the personnel to figure out each process phase. This was followed by the evaluation of the clinical risks, and an estimation of the potential injuries to the patients and the mechanisms adopted to avoid potential injuries.

5.2.3 Exploring the professional staff's perceptions of the quality of the CRM in the hospital

The questionnaire referred to above is based on the Vincent's framework of factors influencing clinical practice and contributing to adverse events, (Vincent et al., 1998). The main aim of the questionnaire is to provide measurements of the seven main frameworks depicted: Institutional, Organization and management, Work environment, Team, Individual staff member, Task, Patient. A copy of the questionnaire appears in the Appendix.

Since it was not possible to use the Vincent et al. (1998) questionnaire to measure the clinical risk factors depicted as it contains no items to this effect, we utilized a questionnaire developed by Sexton et al. (2006a) that explores the personnel attitude concerning the safety culture in hospitals.

The Safety Attitude Questionnaire (SAQ) was initially developed to assess the quality of safety and teamwork related norms and behaviors of individual workers, in a particular setting (Sexton et al., 2006b-c). The safety culture has been defined as "the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of an organization's health and safety management"(Sorra, 2004). The SAQ Short Form version adopted in this research is a single page questionnaire with 36 items and demographics information (role and gender). Each of the 36 items is answered using a five-point Likert scale (Disagree Strongly, Disagree Slightly, Neutral, Agree Slightly, Agree Strongly). The questionnaire comprises six categories: Teamwork Climate (6 items), Safety Climate (7 items), Perceptions of Management (10 items divided in two sections: 5 items for Hospital Management section and 5 items for Unit Management section), Job Satisfaction (5 items), Working Conditions (4 items), and Stress Recognition (4 items). Table 4 shows the SAQ factors definitions including example items for each of the six categories.

Table 4. SAQ factor definitions and example items.

Scale: Definition	**Example items Scale**
Teamwork climate: Perceived quality of collaboration between personnel	Disagreements are appropriately resolved (i.e., not who is right, but what is best for the patient) The physicians and nurses here work together as a well-coordinated team
Job satisfaction: Positivity about the work experience	I like my job This hospital is a good place to work
Perceptions of management: Approval of managerial action	Hospital Management section: Hospital management supports my daily efforts; Hospital management is doing a good job Unit Management section: Unit management supports my daily efforts; Unit management is doing a good job
Safety climate: Perceptions of a strong and proactive	I would feel safe being treated here as a patient I am encouraged by my colleagues to report any

organizational commitment to safety	patient safety concerns I may have
Working conditions: Perceived quality of the work environment and logistical support (staffing, equipment etc.)	This hospital constructively deals with problem physicians and employees All the necessary information for diagnostic and therapeutic decisions is routinely available to me
Stress recognition: Acknowledgement of how performance is influenced by stressors	When my workload becomes excessive, my performance is impaired I am more likely to make errors in tense or hostile situations

To develop a questionnaire that would fit with the Vincent's assumption about the seven frameworks, we added several new items to represent the clinical risk contributory factors that are not represented in the SAQ. Table 5 shows the SAQ items added to each of the Vincent's factor frameworks.

Table 5. The item composition of the new questionnaire to measure the Vincent's frameworks.

Framework	**ITEMS**	**Example items added by authors**
Institutional 4 ITEM	4 item developed by the authors	The lawmaker does not sufficiently protect the patient's right to be treated in compliance with high safety standards
Organization and management 9 ITEM	2 item developed by the authors 7 item from Safety climate [SC] scale (SAQ)	The organizational models adopted by the company reveal a deep culture of CRM
Work environment 11 ITEM	2 item developed by the authors 5 item from Perceptions of Hospital Management [PHM] scale (SAQ) 4 item from Working Conditions [WC] scale (SAQ)	In my Unit there is a good balance between the number of doctors and nurses
Team 9 ITEM	5 item from Perceptions of Unit Management [PUM] scale (SAQ) 4 item from Teamwork Climate [TC] scale (SAQ)	
Individual staff Member 12 ITEM	3 item developed by the authors 5 item from Job Satisfaction [JS] scale (SAQ) 4 item Stress Recognition [SR] scale (SAQ)	The doctors have an expertise and experience appropriate for the complexity of clinical cases treated

Task 3 ITEM	3 item developed by the authors	It is expected to observe a strict medical protocol for the most of the clinical activities carried out in this Hospital
Patient 3 ITEM	3 item developed by the authors	Patients have difficulties in speaking correctly

5.2.3.1 The internal consistence of the new questionnaire scales.

To test the internal consistency of the new scales, an exploratory and confirmatory factor internal consistence analysis was conducted. We launched a reliability analysis using the Cronbach's Alpha Coefficient. In accordance with Nunnally (1978), we consider a Cronbach's Alpha value equal or greater than 0.70 as an acceptable reliability coefficient, although lower thresholds are sometimes used by others. The confirmatory items reliability analysis was conducted and a confirmatory factor analysis (CFA) was performed using the statistical program AMOS 4.0 (Arbuckle, 1999).

The hypothesized factor structure defined in Table 5 was compared with the empirical data, allowing each item to saturate on a single factor, and by setting to zero all other factor loadings. Covariances between the factors were free parameters. To fix the measurement scale of each factor, their variance was set at 1.0. The goodness of fit of the model was verified by the following indices: χ^2; the ratio between χ^2 and the degrees of freedom of the model (χ^2/gl); the comparative fit index CFI (Bentler, 1990); the Tuker-Lewis index TLI (Bentler & Bonett, 1980); the root mean square error of approximation (RMSEA).

The first framework depicted by Vincent et al. (1998) is the Institutional one. The Cronbach's Alpha value is 0.544 (F = 6.584; p = .000), and the corrected item-total correlation range between .20 and .42.

Table 6. Indices of goodness of fit of the model for the new Questionnaire Frameworks (N = 204).

Framework	**Model**	**$\chi 2$**	***gl***	**$\chi 2/gl$**	**TLI**	**CFI**	**RMSEA**	***p***
Institutional	A	0,22	2	0,107	1	1	0	0,898
Organization and Management	A	100,52	27	3,723	.758	.819	.11	0.000
	B	61,60	19	3,242	.841	.892	.10	0.000
Work Environment	A	145,10	44	3,298	.884	.907	.10	0.000
Team	A	73,03	44	1,66	.959	.967	.05	0.004
Individual Staff Member	A	248,01	54	4,593	.619	.688	.13	0.000
	B	98,30	48	2,048	.889	.919	.07	0.000

As Table 6 shows, the model fit to the data in a satisfactory way. The analysis of the standardized estimates of factor loadings reveals that the estimated parameters are substantial (range between .28 and .47) and the standard errors are acceptable (range between .09 and .19).

The second framework depicted by Vincent et al. (1998) is the Organization and Management one. The Cronbach's Alpha value is 0.755 (F = 15.992; p = .000), and the corrected item-total correlation range between .26 and .63. One item shows a corrected item-total correlation equal to .07. As shown in Table 6, the indices of goodness of fit of the hypothesized factor structure (model A) show a fit that is not fully satisfactory. The model was therefore modified (Model B) by taking steps, based on indications from the post-hoc diagnostic procedure (Modification Indices - MI). We deleted the item that showed the low corrected item-total correlation and added the covariance between the errors of the item ORG02 and ORG03-SC. These modifications improved the fit between the model and the data in a satisfactory way. The analysis of the standardized estimates of factor loadings revealed that the estimated parameters are substantial (range between .55 and .79) and the standard errors are acceptable (range between .06 and .16).

The third framework depicted by Vincent et al. (1998) is the Work Environment one. The Cronbach's Alpha value is 0.905 (F = 22.611; p = .000), and the corrected item-total correlation range between .39 and .82. As shown in Table 6, the model fit to the data in a satisfactory way. The analysis of the standardized estimates of factor loadings reveals that the estimated parameters are substantial (range between .35 and .89) and the standard errors are acceptable (range between .06 and .08).

The fourth framework depicted by Vincent et al. (1998) is the Team one. The Cronbach's Alpha value is 0.899 (F = 13.064; p = .000), and the corrected item-total correlation range between .43 and .75. As shown in Table 6, the model fit to the data in a satisfactory way. The analysis of the standardized estimates of factor loadings reveals that the estimated parameters are substantial (range between .36 and .77) and the standard errors are acceptable (range between .05 and .11).

The fifth framework depicted by Vincent et al. (1998) is the Individual one. The Cronbach's Alpha value is 0.791 (F = 86.998; p = .000), and the corrected item-total correlation range between .25 and .61. As shown in Table 6, the indices of goodness of fit of the hypothesized factor structure (model A) present a fit that is not fully satisfactory. The model was therefore modified (Model B) by steps, based on indications from the post-hoc diagnostic procedure (Modification Indices - MI). In particular, we then added the covariance between the errors of the items IND09-SR, IND10-SR, IND11-SR, IND 12-SR. This covariance between the errors of the variables referred to the stress recognition dimension probably means that this factor structure reveals an autonomous sub-factor called “stress recognition”. These modifications improved the fit between the model and the data in a satisfactory way. The analysis of the standardized estimates of factor loadings reveals that the estimated parameters are substantial (range between .33 and .70) and the standard errors are acceptable (range between .03 and .16).

The sixth framework depicted by Vincent et al. (1998) is the Task one. The Cronbach's Alpha value is 0.699 (F = 34.441; p = .000), and the corrected item-total correlation range between .46 and .58. Since this factor has only three items, the factor structure gained from the preliminary exploratory factor analysis was confirmed by the reliability analysis, and it was not verified by a CFA.

The seventh, and final, framework depicted by Vincent et al. (1998) is the patient one. The Cronbach's Alpha value is 0.317 ($F = 1.740$; $p = .177$), and the corrected item-total correlation range between .00 and .30. So, the Cronbach's Alpha value for this scale is very low. Besides, the value of Cronbach's Alpha if we delete the second item is negative (-.048), due to a negative average covariance among items. This violates the general reliability model assumptions. After checking that the item coding reveals no mistakes, we decided to eliminate this factor for future analyses.

5.3 Building the Stock and Flow Model

Based on the CLD designed during the GBM sessions with the hospital management, a stock and flow structure was built, with the main aim to observe the impact of the adopted CRM policies on the hospital performance, both from a financial and non-financial perspective. From a patient safety point of view, the system dynamics model estimates the degree of physical impairment or disability at discharge.

According to Baker et al. (2004), to evaluate the degree of physical impairment or disability at discharge, the physician reviewers were asked to determine, on the basis of evidence in the medical record and their professional judgment, the degree of physical impairment attributable to the adverse event over and above the patient’s disability from the underlying disease on the day of discharge. Conceptually, a patient’s physical impairment or disability at discharge, hereinafter called “patient injury rate”, can be viewed as the sum of two different rates:

- a patient injury normal rate, which expresses the consciousness that every medical intervention can produce a patient injury,
- a patient injury rate due to clinical error, express negative consequence for the patient of a medical intervention, where the injuries produced could have been avoided by the medical staff by strictly following medical procedures and protocols.

Obviously, hospitals can invest in CRM policies that could produce improved results. And, as a direct consequence, hospitals can effectively reduce patient’s injury disability resulting from clinical error. From a financial perspective, the system dynamics model estimates the costs sustained by hospitals for managing the patients’ complaints; for covering legal fees, and the increase of insurance premiums resulting from punitive damages. Following Brennan et al. (1996), the system dynamics model contemplates an average cost for a specific malpractice claim in accordance with the degree of the patient’s physical impairment or disability. The following rules have been adopted about the average value of a payment for a specific malpractice claims, and the indirect cost of legal services, presented in Table 7.

Table 7. The Insurance cost dynamic with respect to the degree of physical impairment or disability due to clinical errors.

Degree of physical impairment or disability	Insurance cost increase (%)	Legal consultant cost (€)
None	0	0
Minimal impairment, or recovery in 1 mo, or both	0	1500
Moderate impairment, recovery in 1–6 mo	0	5000
Moderate impairment, recovery in 6–12 mo	5	8000
Permanent impairment, degree of disability ≤ 50%	20	15000
Permanent impairment, degree of disability > 50%;	80	20000
Death	200	50000

The rise of insurance cost, resulting from payment to patients as ordered by the National Court of Justice, is affected by the patient's age and social status. The actual payment for the degree of patient's physical disability may range between divergent minimum and maximum values. Table 7 shows the average value as estimated by insurance professionals and lawyers. The increase in insurance premiums, following the first compensation sentence episode, is reported in Table 7. However, the percentage increase in insurance premiums rates become lower with each successive episode.

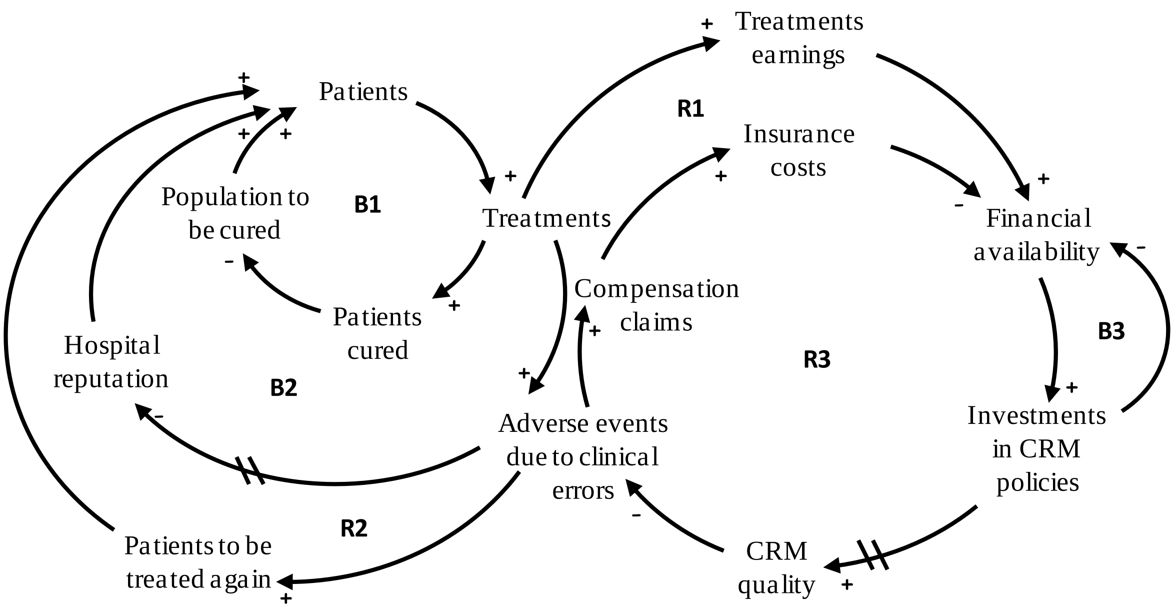
6. Results

6.1 The causal loop diagram

The GMB sessions involving management of the healthcare companies participating in the study allowed us to identify some of the main cause-effect relationships characterizing the organizations' system. As depicted in the Figure 1, the higher the number of people who require a hospital treatment, all other things being equal, the greater the number of patients requiring hospitalization to a certain healthcare company. As a consequence, the number of treatments provided by a hospital increase as well as the number of patients cured reducing the population to be cured (loop B_1). An increase of treatments, due to a higher number of patients, determines a rise in the number of adverse events due to clinical errors, if the percentage of clinical errors does not change. This would worsen hospital reputation and, hence, the number of potential patients (loop B_2).
However, when the number of treatments is augmented, hospitals would acquire more earnings which, in turn, would improve its financial standing allowing for investments in CRM policies. These investments would reduce the liability (loop B_3), and improve CRM quality. This would lead to decreasing the number of adverse events due to clinical errors, and would also have positive effects on the number of patients and, hence, treatments (loop R_1). The effect of investments in CRM policies on CRM quality is not immediate, because it is necessary for the new operating procedures to leave sediment in workers' behavioral

patterns before real improvements can occur. As depicted in the loop R_3, a reduction of the number of adverse events due to clinical errors, stemming from an improvement of CRM quality obtained through investments *in CRM policies*, decreases the number of *compensation claims*. This would lower the insurance premium with a positive impact on *financial revenues* that can be re-invested in CRM policies. In the loop R_2 is described a potential pathological phenomenon that can be caused by the national healthcare system.

Figure 1. The emerged causal loop diagram



Indeed, when *adverse events due to clinical errors* occur, it is possible that the same patients have to be treated again for the same disease or different illness caused by the prior treatment received. It is likely that these patients return to the same hospital to get a new cure, as they may not be aware of the clinical errors and would continue trusting the same doctors. This determines and augments the number of patients, increasing the number of treatments and, all other things being equal, the number of *adverse events due to clinical errors* (loop R_2). These re-treatments bring to the hospital new earnings- in most cases the government is paying for the medical treatments, triggering the previously described loop R_1. Therefore, it can be concluded to a certain degree that it may be economically advantageous for healthcare companies to commit clinical errors, if such errors do not result in any significant negative consequence. In order to prevent such phenomenon, the government should implement a stringent control system to verify as to why certain patients are treated by the same hospital in a brief duration for the same or consequential pathologies.

6.2 The personnel's perceptions about the quality of the CRM in the hospital

Scale means, standard deviations, the proportion of positive scores (≥ 75 out of 100) and alpha values are been estimates through an ANOVA post-hoc analysis (Tukey HSD) presented in Table 8. The psychometric validation displayed that the coefficient alpha ranged among the scales from .55 to .90, where the mean value range from .62 to .73 and the standard deviation ranges from .12 to .17. The percent of positive scores (≥ .75 out of 1) range from 22.5% to 53,4%. The inter-correlation between the questionnaire frameworks has been calculated. The data demonstrate that overall frameworks are highly correlated with one another. In fact, the factor inter-correlation ranged between .39 and .80 (overall statistically significant at the 0.001 level, 2-tailed).
The one-way ANOVA with post-hoc test was employed to explore the difference of the perception about the seven frameworks between the personnel of the three hospitals. The results showed a significant difference between the personnel perceptions with regard to the Institutional framework ($F(2,203) = 36{,}922$, $p = .000$), the Organization and Management framework ($F(2,203) = 41{,}776$, $p = .000$), the Work Environment framework ($F(2,203) = 65{,}179$, $p = .000$), the Team framework ($F(2,203) = 10{,}072$, $p = .000$), the Individual and Staff Member framework ($F(2,203) = 23{,}114$, $p = .000$), and finally the Task framework ($F(2,203) = 43{,}402$, $p = .000$).

Table 8. The ANOVA post-hoc analysis (Tukey HSD) and the percent of positive scores (≥ 0,75 out of 1)

Framework	Hospitals	N	M	SD	Std. Error	95% Confidence Interval for Mean		MIN	MAX	Positive Score (%)
						Lower Bound	Upper Bound			
IST	A	128	0,56*	0,14	0,01	0,53	0,58	0,25	0,80	
	B	35	0,74	0,13	0,02	0,69	0,78	0,41	0,95	
	C	41	0,72	0,14	0,02	0,67	0,76	0,40	1,00	
	Total	***204***	***0,62***	***0,16***	***0,01***	***0,60***	***0,64***	***0,25***	***1,00***	***22,5***
ORG	A	128	0,63*	0,12	0,01	0,61	0,65	0,33	0,85	
	B	35	0,77	0,13	0,02	0,73	0,82	0,50	0,95	
	C	41	0,79	0,11	0,02	0,76	0,83	0,50	0,98	
	Total	***204***	***0,69***	***0,14***	***0,01***	***0,67***	***0,70***	***0,33***	***0,98***	***37,7***
WOR	A	128	0,55*	0,12	0,01	0,53	0,57	0,22	0,82	
	B	35	0,77	0,17	0,03	0,71	0,83	0,38	0,98	
	C	41	0,77	0,13	0,02	0,73	0,81	0,36	0,98	
	Total	***204***	***0,63***	***0,17***	***0,01***	***0,61***	***0,66***	***0,22***	***0,98***	***27,5***
TEAM	A	128	0,70*	0,15	0,01	0,67	0,72	0,24	1,00	
	B	35	0,80	0,16	0,03	0,74	0,85	0,36	1,00	
	C	41	0,79	0,13	0,02	0,75	0,83	0,31	1,00	
	Total	***204***	***0,73***	***0,15***	***0,01***	***0,71***	***0,75***	***0,24***	***1,00***	***53,4***
IND	A	128	0,65*	0,10	0,01	0,63	0,67	0,38	0,92	

	B	35	0,78	0,14	0,02	0,73	0,83	0,50	0,98	
	C	41	0,73	0,11	0,02	0,70	0,77	0,47	0,98	
	Total	***204***	***0,69***	***0,12***	***0,01***	***0,67***	***0,70***	***0,38***	***0,98***	***29,9***
TSK	A	128	0,61*	0,15	0,01	0,58	0,63	0,20	0,93	
	B	35	0,78	0,15	0,03	0,73	0,83	0,47	1,00	
	C	41	0,82	0,13	0,02	0,78	0,87	0,40	1,00	
	Total	***204***	***0,68***	***0,18***	***0,01***	***0,66***	***0,70***	***0,20***	***1,00***	***33,8***

The post-hoc analysis (Tukey HSD) shows that all the means referred to the Hospital C the personnel's perception about the CRM quality are statistically different with both the Hospital A and Hospital B personnel's perception ($p = .000$). No difference, instead, was found between the Hospital A and B personnel's perception (see Table 8).

6.3 The clinical adverse events of the three Hospitals

The data shown in the Table 9, present evidence on the number of compensation claims for each hospital. Further, it shows that the highest percentage of compensation claim occurs in Hospital C, while the lowest percentage happens in Hospital A. These data can be explained by two main factors: first, the number of interventions made by a hospital per year, and second, the technical difficulty of these interventions. In fact, it is well known that a chirurgical intervention is riskier than the medical ones.

Table 9. Number of compensation claims (2008-2010) for hospital and incidence of compensation claim per number of treatments.

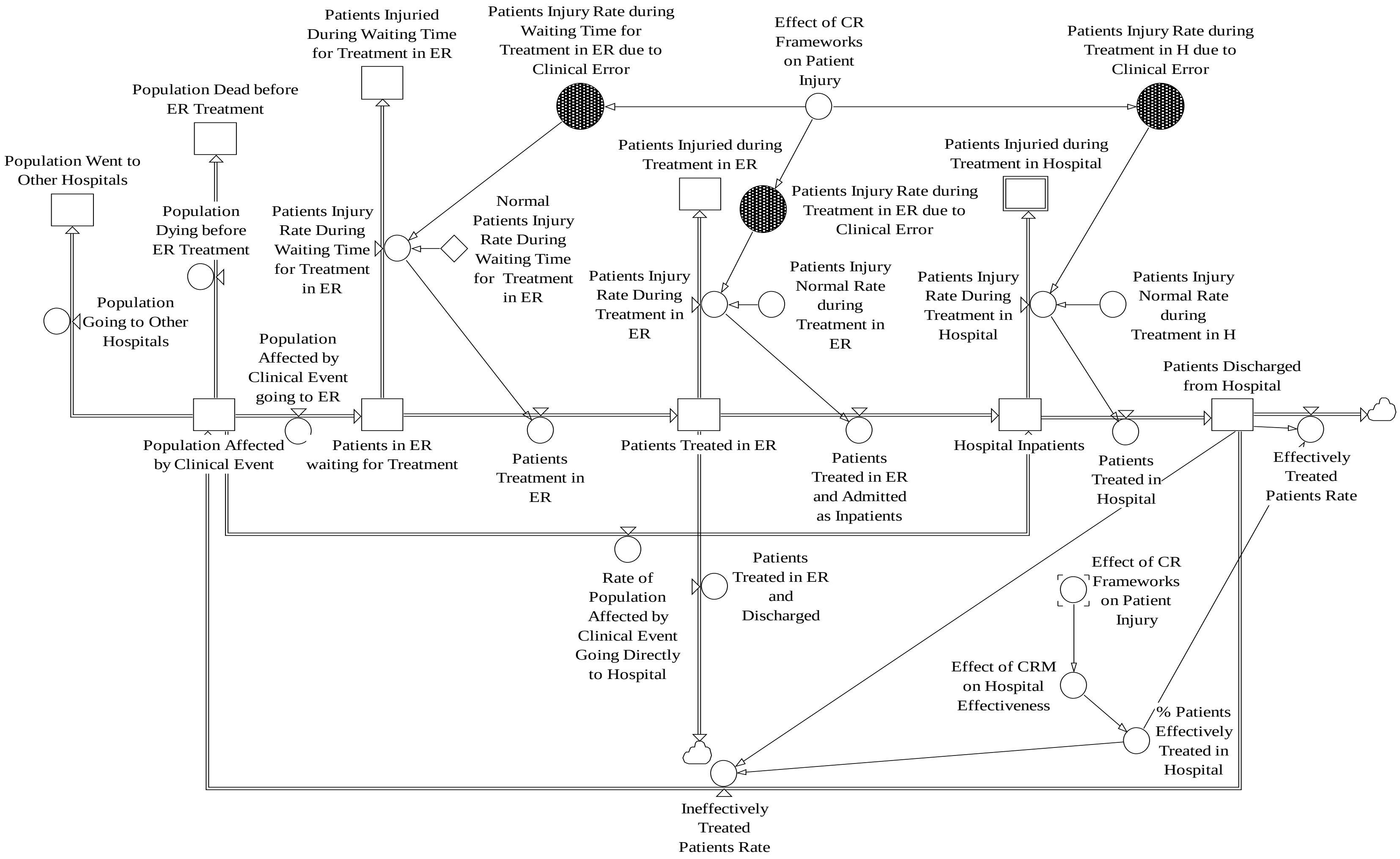
Hospital	Number of Compensation Claims			Number of overall treatments (with the incidence of compensation claims for treatments)		
	2008	2009	2010	2008	2009	2010
A	0	0	0	1016 (0%)	845 (0%)	952 (0%)
B	1	2	4	5298 (0,019%)	5790 (0,035%)	6073 (0,066%)
C	8	14	4	9170 (0,087%)	8413 (0,166%)	7958 (0,050%)

It is important to note that a compensation claim does not necessarily mean that the related adverse event is due to a clinical error made by hospital personnel. However, the data give us a good indication about the dimension of the clinical risk that occurs in these hospitals.

6.4 The Stock and Flow Model

Based on the CLD described earlier, a stock and flow structure has been developed, with the aim of observing the potential impact of some CRM policies on the performance of the hospitals studied in this research. Figure 2 shows a section of the stock and flow structure describing the hospitalization processes. The first stock (on the figure's left), represents the number of people of a specific population- a town- affected by some relevant clinical events that require hospital treatments. As a consequence, these people could potentially become hospital's in-patients. For this reason, from the stock called "Population Affected by Clinical Event" four different out-flows representing the above- mentioned alternatives.
As Figure 2 shows, from each of the three patients' stock (patients waiting for ER, patients treated by ER, Hospital Inpatients) departs two main different flows: the first one represents the progression of the hospitalization process, while the second one depicts the negative consequence of every medical activity, that is, the patient injury rate. Conceptually, the patient injury rate can be viewed as the sum of two different rates: a patient injury normal rate, a patient injury rate due to clinical error.

Figure 2. Stock and Flow Structure related to the Hospitalization Processes and the Effects of Clinical Risk Management on patients' safety.



The “patient injury rate” variable is affected by the clinical risk factors as defined by Vincent et. al (1998). Nevertheless, a deeper analysis shows that just five of them can directly affect the clinical practice as managed by the medical staff of a hospital. In fact, both the “institutional” and “patient” frameworks (that were deleted as described in the previous section) seem to refer to macro and micro scenarios respectively, while the other five frameworks (Organization and Management; Work environment; Team; Individual staff member, Task) refer to factors directly related to medical practice- which can be improved through CRM policies.

It is important to note here that one of the main issues in building SD models is defining the model boundaries. Such boundaries are set according to the main aims of the research. Since, our research is a first attempt of applying SD to CRM from an organizational level of analysis; we decided to build a simple but sensible SD model. Furthermore, this was also acknowledged below in the section on “Conclusions, Implications, Limitations, and Future Directions”. The core point is that the data presented here are based on the preliminary results of a multi-phase research project being undertaken, hence, reflecting the research exploratory nature. Despite the fact that there might be additional processes that could be included in the SD model, these cannot be treated in this paper without renouncing the simplicity of the model which, at this stage of the analysis, is fundamental to describing our research results. In short, these additional processes will be addressed in a future follow up paper.

7. Scenario Analysis

Based on the qualitative and quantitative analysis of the system structure outlined above, four alternative policies have been compared in order to evaluate their potential effects on the company’s performance.

As depicted in Table 5, these policies differ by the degree of improvement of the quality of clinical risk contributory factors, which ranges from 0 (very low CRM quality) to 1 (very high CRM quality):

- in the base-run scenario, the hospitals’ policy is aimed at maintaining the current level of CRM quality;
- in scenario 1, it is hypothesized that the hospitals decide to cut the actual investment in CRM;
- in scenario 2, the hospitals plan to increase the CRM quality by 5% with respect to the current level;
- in scenario 3, the hospitals invest in CRM interventions in order to augment its quality by 10% with respect to the current level.

For the scenario analysis, a six- year time horizon is considered. The first two years (2009 and 2010) of the simulation runs are aimed at replicating the past performance of the participating hospitals. The remaining four years, from 2011 to 2014, are intended to forecast the potential impacts of the examined CRM policies on hospital performance, financial and non-financial. The system dynamics model contains a cost function related to

CRM investments showing that a higher degree of CRM quality improvement indicates a higher amount of money invested in CRM policies.

Insurance costs are also included as described in the CLD in section 6.1. However, because of the complexity of the organizations studied, not all the costs and revenues are included in the system dynamics model. Included are only revenues directly connected to CRM policies and general costs - which are figured out as a percentage of the revenue volume. As a consequence, the reference behavior reproduction was not possible for the net earning variable. The following figures (figures 4, 5, 6) show the simulation results of the four different scenarios. For brevity, the graphs report the results of just one of the three hospitals. However, the simulation results of the three hospitals studied present very similar behavioral patterns and, hence, the following scenario analysis can be representative of the three healthcare companies.

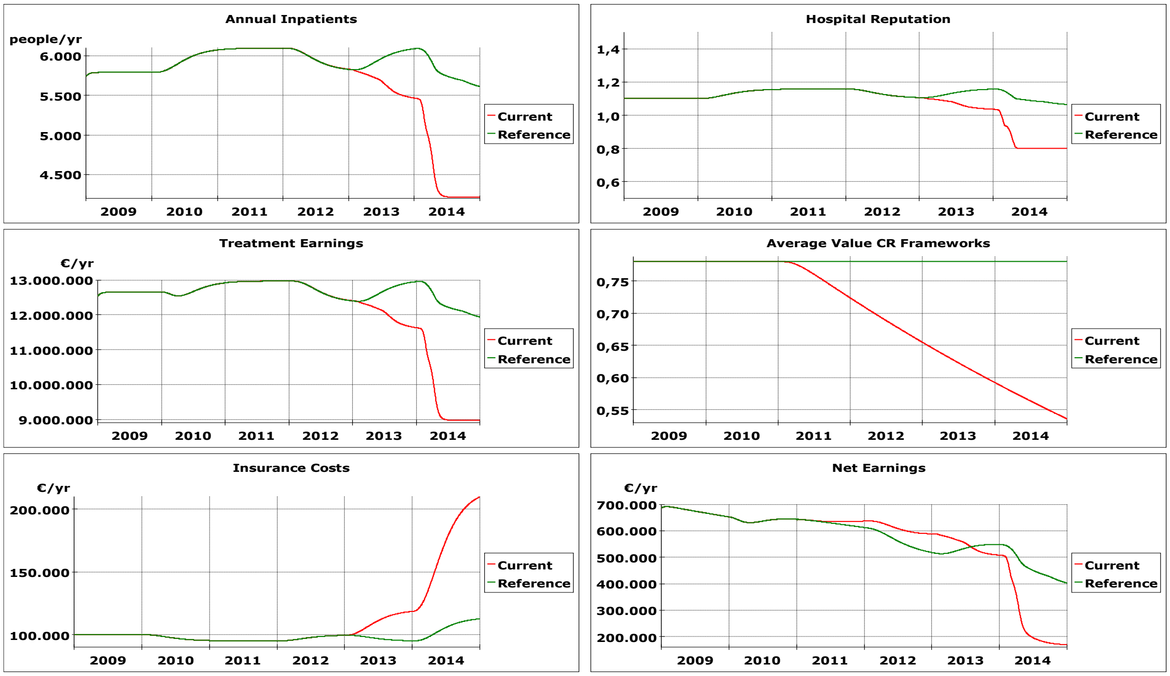
In the base-run scenario, it is assumed that the hospitals maintained the initial level of CRM quality during the simulation time. This policy could imply some minor incidents due to clinical errors that may determine both a worsening of hospital reputation and an increase of insurance costs, which negatively affect economic results. As the reader will note from the behavior of "treatment earnings" compared to the dynamics of annual in-patients, during 2010, the three hospitals experienced a reduction of the average revenue per patient. This reduction was due to a decrease in the amount of funds reimbursed by the regional government to the hospitals for the patient treatments and to a different treatments mix required by patients. This reduction was also the main cause responsible for the worsening of the economic results represented in the simulation results.

In scenario 1 (see Figure 3), the hospitals decide to abandon the CRM practices starting in 2011. The analysis of this scenario is aimed at evaluating the response of the system dynamic model to such an "extreme" policy. This decision would determine a progressive deterioration of CRM quality (indicated as "average value CR contributory factors"), due to obsolescence process of medical tools and practices, which would lead to an increase of clinical errors, a worsening of hospital reputation and, hence, a reduction of the number of people going to the hospitals (indicated as "annual inpatients").

Because of the higher number of clinical errors, hospitals would experience an increase of the "% of treated patients affected by new clinical events" and of the "% of overall complaints". The reduction of treatments earnings, is due to a lesser number of patients, and the increase of insurance costs, due to the higher number of compensation claims, which would lead to a reduction of company "net earnings".

In scenario 2 (see Figure 4), the hospitals decide, starting in 2010, to improve the CRM quality by 5% with respect to their current level. As shown in the simulation results, this decision could produce a positive effect on all the previously examined performance indicators. The comparison between the base run and scenario 2 shows that an investment in CRM policies would bring, in the medium term, higher net earnings. In fact, after an initial reduction of the net earnings due to the investment costs, the economic results would improve because of a higher number of patients and a lower number of compensation claims, and hence, lower insurance costs.

Figure 3. Base Run (Reference) & Scenario 1 (Current) for Hospital B

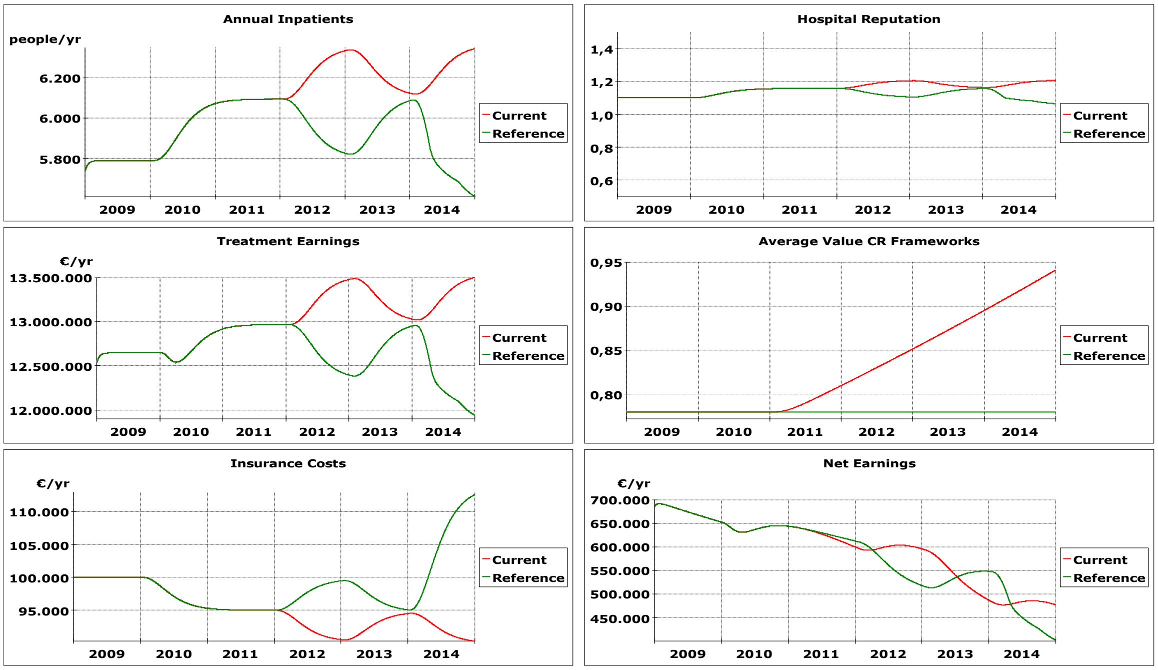


Number of patients compensated by insurance for degree of injury

Time	01/01/2010	01/01/2011	01/01/2012	01/01/2013	01/01/2014	01/01/2015
Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{1,00}	{0,00}
Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{1,00}	{0,00}
Temporary Disability for more than 6 mo	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}	{1,00}
Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}
Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}
Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for more than 6 mo	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}
*Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}
*Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}

In scenario 3 (see Figure 5), from 2010, the hospitals increase the investments in CRM in order to improve the CRM quality by 10% compared to their current level. The comparison between the scenarios 2 and 3 shows that the higher investment in CRM policies represented in scenario 3 would determine a better performance, with respect to scenario 2, in terms of patient safety. However, the higher investment costs required by this policy would not be counterbalanced by higher revenues and insurance costs savings. As a result, this policy would produce a worsening of the net earnings. Consequently, the management could prefer the scenario 2, even though this would imply a lower level of CRM quality. The adoption of the policy described in scenario 3 could be incentivized by the government through offering healthcare companies' tax exemptions or other financial aids.

Figure 4. Base Run (Reference) & Scenario 2 (Current) for Hospital B



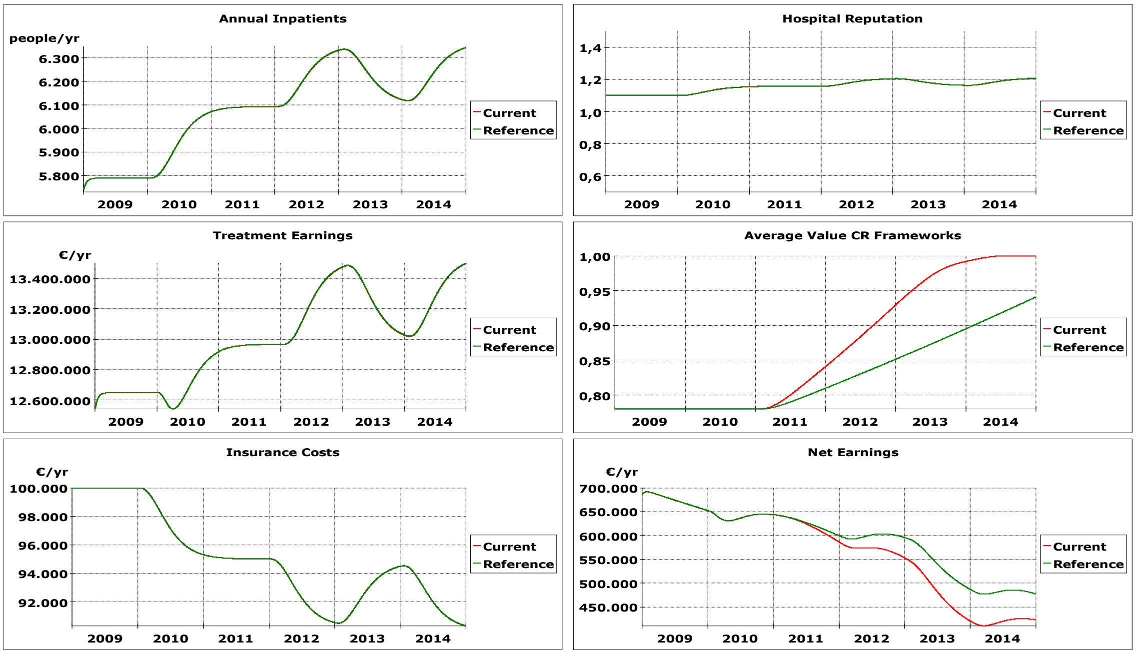
Number of patients compensated by insurance for degree of injury

Time	01/01/2010	01/01/2011	01/01/2012	01/01/2013	01/01/2014	01/01/2015
Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
Temporary Disability for more than 6 mo	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}
Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for more than 6 mo	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}
*Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}
*Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}

At this stage, we would like to comment on why we had to collapse the different factors measured in the questionnaire into a single variable that represents CRM quality.

Coherently with the choice about the model boundaries definition, we decided to represent the different CRM factors by a proxy variable that takes into account their average values. This decision emanated from the lack, in the literature, of data about the specific values describing the contribution of each factor to the overall variance of CRM quality. This decision is also based on three premises: First, there is an explicit acknowledgement in the literature about the ultra-complexity of the subject matter. As noted earlier, recent work suggests that despite the multitude of initiatives, programs, systems, and tools that can be viewed as elements of CRM; there is a lack of knowledge concerning their implementation in hospitals (Briner, 2010). Second, we could have tried to estimate the value of these parameters; but this is so complex that will require several researchers focused on this specific topic. Third, this decision cannot be judged as a signal of disjunction between questionnaire and SD pieces, but merely as the inevitable consequence of the lack of empirical data about the value of these parameters.

Figure 5. Scenario 2 (Reference) & Scenario 3 (Current) for Hospital B



Number of patients compensated by insurance for degree of injury

Time	01/01/2010	01/01/2011	01/01/2012	01/01/2013	01/01/2014	01/01/2015
Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
Temporary Disability for more than 6 mo	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}
Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for less than 1 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for 1 to 6 mo	{0,00}	{1,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Temporary Disability for more than 6 mo	{0,00}	{0,00}	{0,00}	{1,00}	{0,00}	{0,00}
*Permanent Disability for less than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Permanent Disability for more than 50%	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}
*Death	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}	{0,00}

A summary of our analytical findings can be discussed as follows: In the scenario analysis section, we explained that the performance indicators monitored to measure the potential impact of CRM policies on financial and non- financial results present similar behavioral patterns in the three hospitals. However, we need to take some considerations into account- as noted below. The questionnaire results show that the two private hospitals present a higher level of CRM quality compared to the third public hospital. This is confirmed both from the personnel perception questionnaire results and by the number of compensation claims received by the hospitals. This difference in the CRM quality can be explained by the higher consciousness in the private hospitals' personnel about the relevant impact of a serious clinical adverse event on the financial stability of the healthcare organization they work for.

In other words, the adverse event is perceived not only as a professional failure but also as a potential threat to their workplace. Moreover, the financial support from the regional government to the public hospital reduces the perception of the economic impact of an adverse event and, hence, personnel's attitude towards CRM practices. For this reason, the public hospital presents greater margins of CRM quality improvement that require more investments in terms of both medical equipment and personnel training and motivation programs. Therefore, it would be useful to develop CRM laboratories linking both private and public hospitals aimed at creating communities of practice- where sharing best practices and fostering organizational learning.

8. Conclusions, Implications, Limitations, and Future Directions

We believe that our study has a broad appeal for researchers. Globally, while patient's safety and the quality of care declined, the aging population has substantially increased, so did the skyrocketing cost of healthcare. The complexity of the profit maximization phenomenon at the expense of patient's safety has become a pressing issue requiring remedial action. Greater awareness and concerns over the future of health care, in part, steered us to study this thorny universal problem.

Our research findings suggest that it would be feasible for these companies, to invest financial resources to achieve a certain level of CRM quality. However, according to the simulation results, increasing the level of CRM quality could be at the expense of financial bottom-line. Also, the financial costs related to additional investments may be higher than the marginal benefits the companies could gain. As a consequence, if the national healthcare system aims to accomplish higher level of CRM quality than the healthcare companies' "breakeven" threshold, it should make these investments more feasible and sustainable through tax exemption policies, or other financial aid measures.

Considering the difficulty of having access to any hospital for the purposes of academic research and data collection, we believe that gaining access to the three hospitals represents a significant progress toward further exploration and understanding of CRM. Also, the behavioral similarity among the three hospitals supports the assumption that our research results can be extended to other hospitals.

The development of this research project was aimed at comparing different combinations of CRM investments, and an investigation of their impacts on healthcare companies' cash flow. Similar to other studies, our research has a number of limitations, that can be addressed in future research. One limitation is that the data presented here are based on the preliminary results of a multi-phase research project being undertaken, hence, reflecting the research exploratory nature.

A second limitation is represented by the model boundaries. Indeed, some system variables that may influence the performance of the hospitals have not been considered, such as the role of the Regional Healthcare Administration, the role of Unions, patients associations, etc. However, these external influences were not considered essential for the goal of the analysis, since they are beyond the hospitals' management control. Nevertheless, despite these limitations, this paper delivers results with implications for the application of system dynamics methodology to CRM.

A third limitation relates to the fact that we had to represent the different CRM factors by a proxy variable that takes into account their average values. As noted earlier, while this decision emanated from the lack of empirical data in the literature about the value of these parameters, it, nevertheless, represents a research limitation. Finally, the ultra-complexity of the subject matter; and the paucity of quantitative research-based studies in the literature, was an issue. However, the scarcity of material on the subject matter turned out to be a twoedge sword: on the one hand; it is a constraint in dictating the "exploratory" nature of the study; and yet; on the other hand; it enhances the study's contribution to the field via charting an "unexplored" path to learn more about the elements of a paradigm for navigating an "underdeveloped" research stream.

In sum, the academic and practical implications of our research can be summarized as follows. CRM practices do not take into account the cost elements and their influence on personnel management. Such conditions may foster wrong evaluations leading to the postponement of the introduction of procedures aimed at improving the healthcare companies' risk profile. Furthermore, healthcare companies' managements experience serious difficulty in quantifying the benefits gained from investments aimed at reducing the clinical risk. Therefore, it is necessary to provide healthcare companies' managements with a systemic and multi-dimensional approach that supports cost-benefit analysis of CRM policies.

The international nature of the study may open the door and stimulate other researchers to undertake comparative research studies in cross-cultural settings. We are calling on future researchers to investigate and carry-on experimentation with system dynamics as a significant paradigm for uncovering real performance indicators of operations management effectiveness - not only from the perspective of organizational internal resources, but also the contextual drivers and constraints imposed by the organization's environments.

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