

Synergistic Development of Information Systems and Quality Management in Healthcare: Exploring the Multiverse

João Barata

*CISUC, Department of Informatics Engineering, University of Coimbra
ISMT, Miguel Torga Institute
Coimbra, Portugal*

barata@dei.uc.pt

Paulo Rupino da Cunha

*CISUC, Department of Informatics Engineering, University of Coimbra
Coimbra, Portugal*

rupino@dei.uc.pt

Sofia Barata

*CTCV, Technological Center for Ceramics and Glass
Coimbra, Portugal*

sbarata@ctcv.pt

Abstract

We present an approach for the synergistic development of information systems (IS) and quality management systems (QMS) in healthcare. Canonical action research is our mode of inquiry to address the multidimensional hospital quality: ISO 9001 certification, hospital accreditation, and IS quality. Our study tests and extends the ISO₂ approach in two hospital services: emergency and pediatric care. Hospitals present challenging realities in their complex socio-technical structure. Our approach suggests self-evaluation by hospital professionals and the contrast of opinions to identify IS development opportunities, while contributing to quality awareness and the adoption of quality principles in business processes. The proposed approach allows (1) self-evaluation, (2) joint design, and (3) continuous improvement planning of hospital processes. Moreover, it supports diverse quality models in healthcare and the development of heterogeneous IS solutions in different maturity stages.

Keywords: Healthcare, Information Systems, Quality, Multiverse, Synergies.

1. Introduction

The adoption of quality models is a priority for healthcare [18]. General quality management standards such as ISO 9001 [20] are of increasing interest for process approaches in clinical contexts. There are several accreditation programs designed for health services that require self-evaluation, regulatory compliance, and information transparency. Moreover, quality practices are increasing IS development (ISD) pressure to (1) provide timely solutions in support of the quality efforts, (2) improve and redesign healthcare processes supported by information technologies (IT), and (3) adopt quality principles in ISD.

ISD takes place in regulated contexts that may differ in knowledge expertise, organizational structure, project, team, and individual behavior [10, 22]. Regulations can be enforced, for example, in the case of legal requirements, or they may be voluntary, for instance in the case of adopting quality standards, codes of conduct, and best practice guides. The high number of variables in IS design and operation makes ISD methodologies even more relevant nowadays, presenting the potential to be adapted into specific situations [4].

The influence of ISD and quality management systems (QMS) is mutual. On the ISD side, quality models have been recently applied, for example, in the field of model driven web engineering [14], and joint development approaches for IS and quality [5]. On the QMS side, several authors have studied the positive impact of IS, for example [12] which suggests that managers should adopt quality techniques to improve IS quality. In fact, Ray Paul's definition

[26] that “*the IS is what emerges from the usage and adaptation of the IT and the formal and informal processes by all of its users*” would fit perfectly in modern quality models that are process oriented, require the involvement of all their users, and greater than ever IT support.

The entanglement of the IS and the QMS raises a question: *How to synergistically develop the IS and the QMS in hospitals?* In this paper we propose a solution with the ISO₂ approach that was applied in two services of a district hospital: emergency and pediatric care. The reported case includes (1) ISO 9001 certification – under implementation in the emergency service; already implemented in the pediatric unit; (2) ACSA accreditation (simultaneously in both services); and (3) the IS quality [31] development program.

As [13] puts it, “*The structure of the multiverse is determined by information flow*”. In the case that we report, we found “multiple worlds” for which we used the multiverse metaphor. The term multiverse (or many worlds) in quantum mechanics refers to the theoretical existence of multiple universes, each one with their own laws. This theory suggests the possibility of multiple realities occurring in parallel universes. In spite of being in the structure of the same hospital, influenced by the same policy, the services that were included in our study have significant differences: in the “laws” that influence their reality, in the focus of their processes, in the motivation of their professionals, and in their IS support. However, the hospital “multiverse” also includes common “laws” which are established by their quality policy. It then becomes essential to understand the design-reality gap [17].

The remainder of this paper is organized as follows. In section 2 we present the background, describing models of quality management in healthcare and a review of potential synergies between quality management and ISD. Next, we present the action research approach that we selected, namely, the canonical form described by [32], validated according to the principles and criteria suggested by [11]. Section 4 details our action research cycle, presented according to the sequence of action research steps that we conducted. Section 5 concludes the paper, states the study limitations, and opportunities for future work.

2. Background

2.1. Quality Management in Healthcare

A number of quality models are adopted in healthcare. These include (1) more general certification approaches, for example with ISO 9001, (2) excellence models based in TQM, namely, the European Foundation for Quality Management (EFQM), the Deming Prize in Japan, the Malcolm Baldrige National Quality Award (MBNQA) in USA, and (3) healthcare accreditation programs such as the pioneer Joint Commission International (JCI), the King’s Fund Health Quality Service (KFHQS) in the UK, and the General Hospital Grade Accreditation (GHGA) in China [18, 24]. There are models specifically developed for healthcare that include a commitment with self-assessment, for example in the ACSA accreditation, the Australian Council on Healthcare Standards, Haute Autorité de Santé, and Accreditation Canada [1]. Moreover, quality involves the conformity with a plethora of national and international regulations, either voluntary (e.g., standards, regulations, codes of practice) or enforced (e.g. legal requirements) that shape the healthcare regulatory space.

ISO 9001 is one of the most used models to implement a certifiable QMS and there are claims of its benefits in healthcare, for example, increasing patients' satisfaction, preventing medications-related incidents, reducing unscheduled returns to the hospital, diminishing complaints, decreasing medical equipment failures, and improving compliance to protocols [29]. The next ISO 9001 revision (to be released in late 2015) is expected to increase the focus in process management, detailed definition of the healthcare context (e.g., applicable regulations), and the adoption of quality principles in daily practice [19], potentially increasing the standard interest for healthcare. However, [28] states that ISO 9001 effectiveness in healthcare requires clarification. ISO 9001 is highly dependent on the organizational IS and there are proposals suggesting that they should be jointly designed [5].

Accreditation programs for healthcare such as JCI and ACSA provide specific guidance for healthcare practice and evaluation, for example, using quality checklists. There are also specificities to consider in eHealth processes. Nevertheless, as presented by [18], there are complementarities between accreditation programs and process oriented approaches suggested by ISO 9001, with the potential benefits in creating a QMS that is more adapted to each hospital context, policies, and quality culture. One of the challenges for hospitals that adopt multiple quality models is their integration [18, 30]. As suggested by [21] it is possible to consider (1) *“compatibility with cross-references between parallel systems”*; (2) *“coordination of business processes”*; and (3) *“an organizational culture of learning, continuous improvements of performance and stakeholder involvement related to internal and external challenges”*.

A literature review addressing the thematic of quality models in healthcare [25] found that the main obstacles were cultural aspects, excessive bureaucracy and hierarchical structure, leadership problems, poor planning, and *“difficulties involved in evaluating healthcare processes and outcomes”*. According to [25] *“culture is one of the most frequently mentioned difficulties to TQM implementation in healthcare sector. Therefore, organisational culture is the most often ignored component of TQM during the course of TQM implementation. There are powerful sub-cultures such as physicians, nurses and paramedics who have their own interests. They define quality differently and follow specific ways to achieve it”*. The authors conclude that it is necessary to develop a quality culture and an adequate IS, providing training and the support technologies to incorporate quality principles into daily processes. A recent study presented by [34] reinforces this perspective presenting key factors for quality management implementation: *“top management involvement, inter-department communication and coordination, teamwork, hospital-wide participation, education and training, consultant professionalism, continuous internal auditing, computerized process, and incentive compensation”*. However, these studies do not provide practical guidance on how to proceed in practice. Quality models must consider the specificities of hospitals, namely the ones described by [33]: the lack of time, lack of quality-related skills, and, sometimes, even lack of motivation of doctors and nurses for quality management issues. In such a demanding context that is focused in the patient health, the synergistic development of the IS and the QMS is critical, otherwise, both systems may become a burden for hospital professionals.

2.2. Synergies Between Information Systems and Quality

Achieving more than a sum of the parts is a current concern in ISD and quality [5]. For example, [27] found that IT competences have a positive influence in the implementation of quality principles, namely the process approach, customer focus, and human resource management. IT impact on organizational performance can be achieved through effective quality practices support and *“managers are able to take advantage of the synergies derived for implementing both QM and IT programs”* [27].

The IS and the QMS may require similar organizational cultures for their success, especially in the promotion of proactive actions and people involvement [6]. However, the difficulty increases when we need to integrate different quality models, in different healthcare services, each one with their specificities, multiple priorities, and disparate systems implementation paces. According to [31], a holistic enterprise quality must address different dimensions of IS quality, including infrastructure, software, data and information, administrative, and service quality.

The information requirements and a framework for supporting ISO 9001 in healthcare was presented by [23], suggesting a three-fold approach to address the requirements of (1) people, (2) processes, and (3) legal and service agreements. Nevertheless, [23] focuses on IS in support of the QMS, not offering practical tools that hospitals can use and not totally exploring the possibilities of quality in support of ISD practices. Information technology has an important role in facilitating quality disclosure and transparency in hospitals [2] and there are recent studies of healthcare ISD for quality [15] but, once again, we could not find in the

literature a practical and concrete way to apply the lessons in daily hospital practice nor empirical cases that studied the effect of such type of synergistic approaches.

3. Research Approach

Our research objective is to propose an approach that eHealth experts and healthcare professionals can use to explore IS/QMS synergies. Complementarily, we intend to (1) understand the context of quality models in healthcare, (2) empirically study how a common approach for quality and ISD can be used in practice. According to [8], creating or changing a systems development approach is impossible from a socio-organizational viewpoint without intervening in the real world to test it. Action research is an approach that simultaneously aims to improve a problem situation in the target organization, and contribute to scientific knowledge [11, 32]. The ideal domain of action research is characterized by a social setting where (1) the researcher is actively involved, with expected benefit for both researcher and organization; (2) the knowledge obtained can be immediately applied; and (3) the research is a process linking theory and practice [8].

For our research we have selected the canonical action research, characterized by five phases of *Diagnosing*, *Action planning*, *Action taking*, *Evaluating*, and *Specifying learning* [32]. Learning occurs during the entire action research cycle and consist of summing up and documenting of the findings, contributing to theory and practice [11, 32]. One of the principles suggested by [11] to ensure rigor and validity is the existence of a frame of reference, for which we elected the ISO₂ approach as described in Table 1.

Table 1. Summary of ISO₂ steps (adapted from [5])

Step	Description
1	<i>Prepare the mindset:</i> Contribute for the team coordination, management commitment and an awareness campaign;
2	<i>Diagnosis (as-is):</i> Identify current quality and IS practices, quality, and other contextual requirements. Define and assess the current processes from the users perspective;
3	<i>Define a Vision (ought-to-be):</i> Define quality and IS policies. Create the desired process map;
4	<i>Design (to-be):</i> Detail each process and indicators. Establish the plan and ISD objectives;
5	<i>Source the systems:</i> Develop the IT artifacts and the QMS documents;
6	<i>Deploy:</i> Implement the systems, train, internalize, transfer to daily practice;
7	<i>Evaluate:</i> Audit, test, validate, and perform user acceptance. Restart to improve.

Table 2 describes the subset of ISO₂ artifacts that we have selected for use in this research.

Table 2. Summary of ISO₂ artifacts used (adapted from [6, 7])

Artifact	Description
O₂ principles evaluation	The purpose is to assist in the definition of the system vision, identifying the main principles of the organization and its vision in each process;
O₂ principles development checklist	This artifact includes the evaluation of principles adoption, the evidences, and the ISD actions to ensure conformity;
Checklist for auditing IS quality	Understand if requirements are implemented properly and if quality principles are actually being applied in different dimensions of the IS. Aims at identifying the gaps between what is intended and what is done in practice.

The next section describes our action research cycle, the extension that we made to the ISO₂, originally proposed for research institutes and industrial contexts, and the findings of its adoption in healthcare setting.

4. Exploring the Multiverse: Development of IS/QMS in Multiple Realities

4.1. Client-System Infrastructure

Our study of the research setting included (1) an initial interview with the quality and risk management commission (QRMC), (2) document analysis, and (3) field observation. According to the last official hospital report (2011-2013), they employ 621 professionals and have 154 beds. The hospital is certified by ISO 9001:2008 including (1) healthcare – pediatric care, rehabilitation medicine, day hospital, surgery specialties, and medical specialties, (2) support services such as pharmacy, sterilization, social service, occupational medicine, and (3) different areas of technical support, logistics, and management. In the last decade the hospital was involved in the Joint Commission International accreditation and, more recently, their efforts are to implement ACSA Accreditation Model by 2016.

Top management defines the main strategy and policies that the hospital QRMC must follow in their QMS development. QRMC priorities are the ISO 9001 and ACSA, nevertheless, the commission must also develop the risk management system, attend to specific governmental guides for healthcare, and follow a plethora of legal requirements. There are complex information flows that are internal to the hospital and distinct for each service, that vary with the adopted quality models and regulations, and differences in the supporting IS. The communication between services – each one with a local QRMC – and with the external environment (e.g., auditors and local community) is demanding. The next section describes our diagnosis of the situation.

4.2. Diagnosing

One hospital, the same quality policy. However, there are many differences to attend to. First, not all hospital services are certified by ISO 9001 (e.g., emergency), exhibiting different maturities in quality management. Second, there is a heterogeneous portfolio of IT solutions, most of them integrated, but with weaknesses in supporting quality indicators and audits. According to the QRMC, quality is not a main concern of the IT department, which is mostly focused on clinical processes (e.g., helpdesk and platforms such as the digital clinical process), leading to the development by QRMC of countless spreadsheets to support quality. Spreadsheets have spread to each certified service and are now the source of new problems, because (1) present difficulties to compile reliable and timely indicators, (2) do not ensure information quality, and (3), require extra work for quality certification and accreditation.

Complaints have significantly increased in the past years, at an average of 18% / year, mostly regarding medical staff (47,5%) and management (38%). This effect is illustrated in Figure 1.

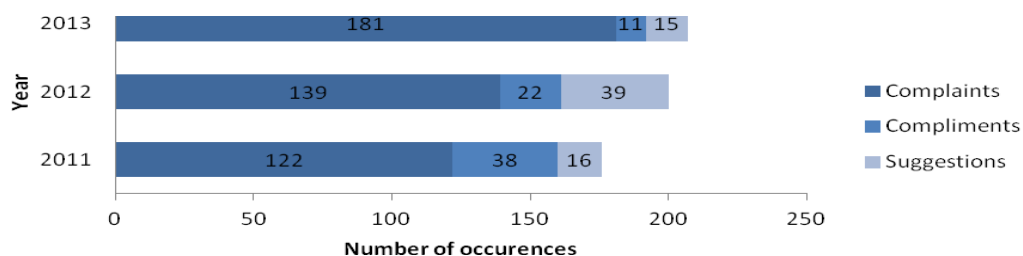


Fig. 1. Complaints, compliments, and suggestions (Source: hospital report).

On the one hand, the hospital faces a period of economic restrictions and staff reduction. Quality can be compromised, with potential risks for the patient. For example, (1) the extra work by professionals for information gathering and processing consequently reduces their time for patient care, (2) there is a potential decrease in service quality if quality indicators are not available for hospital processes, and (3) there are potential threats in information quality if

IT solutions are not aligned with the standards (e.g., timeliness, reliability, completeness). On the other hand, there are opportunities. We could confirm the exceptional staff dedication and interest in quality improvement. Moreover, ISD can provide approaches to improve the problematic situation, assisting hospital professionals.

A summary of the most relevant issues in our diagnosis follows:

- Heterogeneous QMS: not all the departments are already certified;
- Motivation in certified services may decline due to the time spent in errors and quality bureaucracy;
- The lack of involvement and the difficult communication between IT and quality managers seems to be an old and recurrent problem [5];
- Services that are starting their quality initiatives need to train all staff members and integrate self-assessment due to the sequent ACSA accreditation [1];
- There is a need to improve IS quality in different dimensions [31], to comply with quality disclosure needs in healthcare;
- Multiple regulations, different quality model focus (ACSA for more advanced services, ISO 9001 for non certified services) requires integration [21, 30];
- Quality policy must be applied to all processes of the hospital. The hospital will migrate to the new version of ISO 9001 expected to be released in late 2015 [19];
- Self-assessment must be implemented for ACSA accreditation [1]. There is an opportunity to include self-assessment in ISO 9001 (even if not required by it);
- IS requirements must be identified for each healthcare process and a joint development plan must be produced. Actions must address both the IS and the QMS.

The quality and risk commission was enthusiastic to adopt an approach to joint develop their IS and their quality system according to ISO 9001 and ACSA. The next section presents the action plan sketched by researchers and practitioners.

4.3. Action Planning

The complexity of the setting did not allow us to start using ISO₂ for each process of the hospital. For example, in the two services that we addressed, the same process (e.g., emergency and pediatric emergency) has differences, it is described in different levels of detail (different procedures in emergency and pediatric care) according to the professionals' needs and the level of development of their quality system. Moreover, IT is integrated in both services but we found different problems. For example, in the emergency process, adult and children have different requirements and IT support (e.g., for internment). Additionally, the original ISO₂ was proposed for the ISO 9001 standard and not for a context that includes health accreditation. Our action plan is presented in Figure 2.

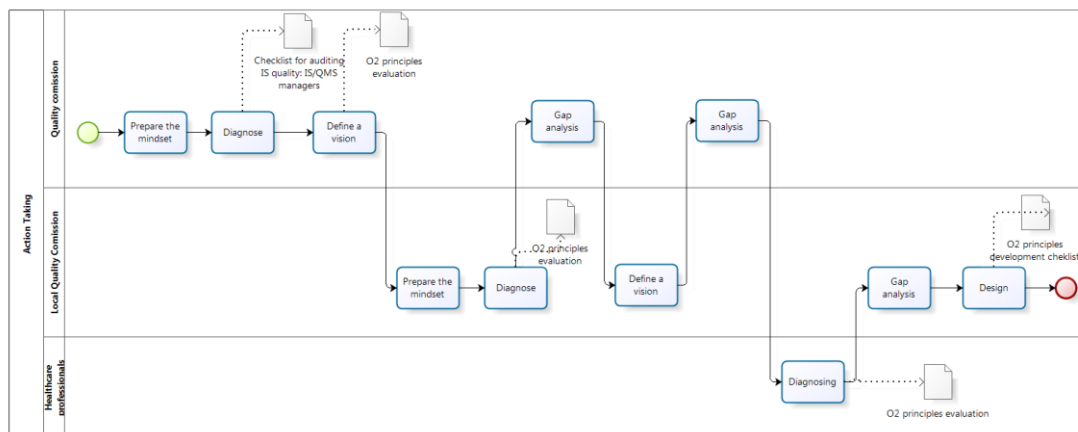


Fig. 2. Action planning steps.

Figure 2 presents the adaptation of the initial four ISO₂ steps, including gap analysis [17]:

1. Prepare the mindset. Present the ISO₂ approach to the quality commission, involving both quality and IS professionals in the initial phases [3];
2. Diagnose the existing IS and QMS according to the overall hospital strategy and the specificities for each selected hospital service;
3. Define a vision according to the administration strategy and quality policy. At this stage we defined the key principles and standards to follow by the entire hospital.
4. Prepare the mindset. Present the ISO₂ approach to each local QRMC;
5. Diagnose local services according to the set of principles common to the entire hospital, starting with the manager and chief nurse in each service. This task involves a gap analysis [17] between the local service perspective and the QRMC perspective;
6. Define a vision according to the local service (specific checklist). This task also involves a gap analysis [17] between the service and the QRMC perspective;
7. Diagnose the IS and the QMS with the service staff. It is an opportunity to train hospital professionals in the IS and QMS concerns, especially in the implementation of new quality models being faced (ACSA and ISO 9001 in emergency);
8. Contrast the perspectives: QRMC *vs.* local QRMC, local QRMC *vs.* staff; local QRMC emergency *vs.* local QRMC pediatric care; emergency staff *vs.* pediatric staff;
9. Design the IS and the QMS, integrating the perspectives of the project participants.

The output is an action plan that IS and QMS professionals should put into practice. The next section describes the action taking in emergency and pediatric care.

4.4. Action Taking


The first phase was conducted with the hospital QRMC (steps 1-4 as described in the previous section). We created the O₂ principles evaluation artifact and deployed the questionnaire presented by [7] to diagnose the hospital IS quality. At this point we identified that (1) the hospital quality policy was not including all the principles suggested by ISO 9001 (decision based in facts) and the new ACSA accreditation, and (2) IS quality had deficiencies in infrastructure, software, and service quality. An extract of the O₂ principles evaluation is presented in Table 3.

Table 3. O₂ principles evaluation (excerpt)

Main Principle	Quality model	Hospital Quality Culture
1. Patient focus	ISO 9001 (Organizations depend on their customers and therefore must understand their present and future needs, satisfy their requirements and make an effort to exceed their expectations); and ACSA accreditation Group I (the person) II (person-centered activity), and III (professionals)	To provide quality health services that are accessible and timely (...), with procedures and practices based in humanist principles, responsibility and dialog (...)
<i>(...) main principles that guide IS/QMS</i>	<i>(...) description of the most relevant quality models affecting the principle</i>	<i>(...) quality policy available to the public</i>
7. Safety and Risk management	ACSA (e.g., support processes); ISO 9001:2015 expected revision; Several risk management regulations	The hospital develops an integrated risk program considering patients, professionals, and society, at all levels of the organization

Table 3 aims at the understanding of the main principles that the hospital must implement (vision) in every single process, independently of the realities of each service and model.

The second phase, involving the local QRMC (medical responsible and chief nurse) for emergency and pediatric care allowed us to explore the principles adoption at a local scale. We asked the local QRMC to propose a set of checklist items to diagnose each quality principle in their processes. The task took two weeks and the checklist was then validated / changed by the QRMC before deploying it to all the systems users. The checklists are illustrated in Figures 3 (emergency) and 4 (pediatric) for one principle.

Quality Principle	Goal/Rule Checklist	Evaluation*	Evidences	ISD / QMS action	Action Stage
patient focus	Patient is treated by his/her name	3	Staff inquiry	Change the place of patient name in the web form X for better visibility	
patient focus	Triage is executed according to the patient complaints	4	Manchester triage		

*evaluate from 1(inexistent), 2(weak), 3(satisfactory), 4(good), and 5(very good)

Fig. 3. O₂ principles development checklist (extract for emergency – patient focus).

The O₂ principles development checklist is an ISO₂ artifact that we did not change. It allows the evaluation, evidence report, and the proposal of IS/QMS actions for each principle / checklist item. The structure is aligned with ISO 9001 (PDCA approach [20]) and ACSA (evidences, actions). Figure 4 presents the case of pediatric care. It is interesting to see the subtle difference in the first line for both services.


Quality Principle	Goal/Rule Checklist	Evaluation	Evidences	ISD / QMS action	Action Stage
patient focus	Patient is treated by the name that he/she prefers	4		The IT platform needs this new field	

Fig. 4. O₂ principles development checklist (extract for pediatric care – patient focus).

Each service can freely adapt the checklist to its own reality. We can identify that the “patient focus” principle can have differences in each service, even for something as simple as the name used for each patient. Children can have diminutive names and one of the service principles is to facilitate children internment, putting their interest above all. The IS must attend to these differences and, as we can identify from this table, IS and QMS managers must not ignore specificities that may occur in the same type of process. Our study identified several other synergistic development opportunities for the IS and the QMS, including integration aspects between nursing IT platforms and medical staff’s. It is also important to consider possible gaps between professional specialties, therefore, we suggest identifying each survey (that is anonymous) with the respondent function. Afterwards, the diagnosis was extended to the staff of each service. In Figure 5 we illustrate the results for emergency and the principle evaluation gap when compared to the hospital (global) QRMC evaluation.

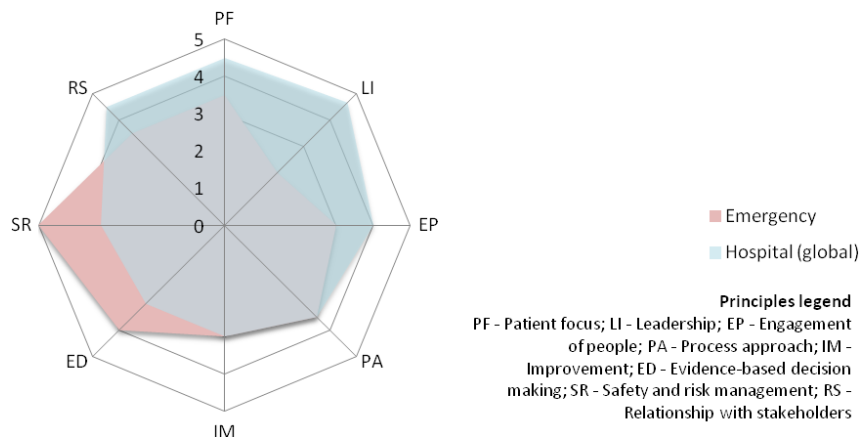


Fig. 5. Principles gap (QRMC – local QRMC for emergency service).

Figure 5 exemplifies the possible differences of the same principle adoption the hospital level and at the local (service) level. In this case we have found major differences in leadership evaluation (possible improvement action: training) when compared to the hospital (global) grade. Conversely, in the case of safety and risk management, the emergency service can be an example of best practices to other services (enabling service benchmarking of each quality principle). What emerges from our measurement is an assessment of systems dimensions and a set of actions for the IS/QMS synergistic development. During our research we also found the interest in proposing a new ISO₂ artifact, as exemplified in Figure 6.

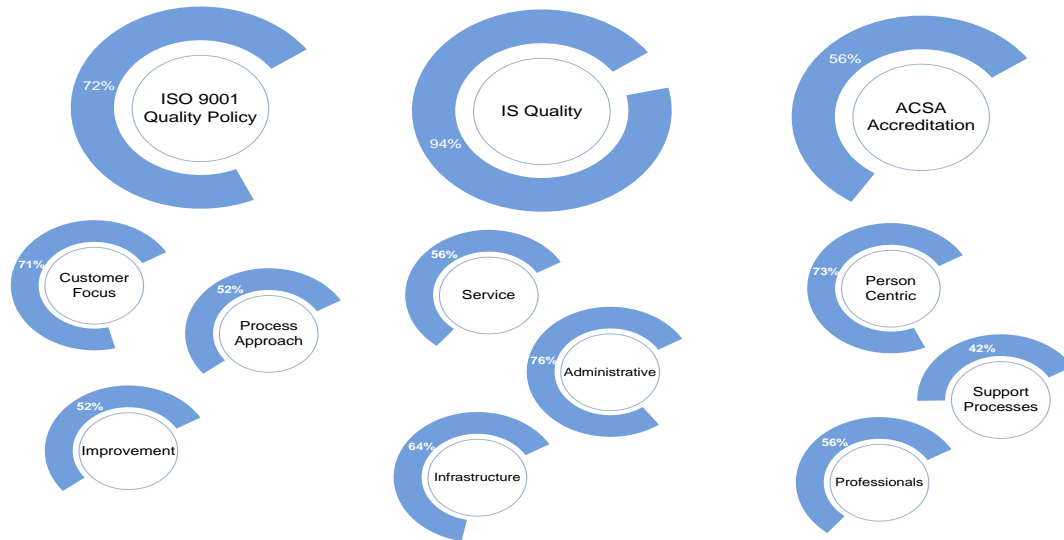


Fig. 6. IS/QMS synergies dashboard (with the option to drill-down for each service).

At this stage, the dashboard is merely conceptual, to represent the development stage of different dimensions of IS quality [31] and the adopted quality models (ISO 9001 and ACSA in the present case), according to each selected dimension. The integration of different realities in the hospital multiverse is explained in Figure 7.

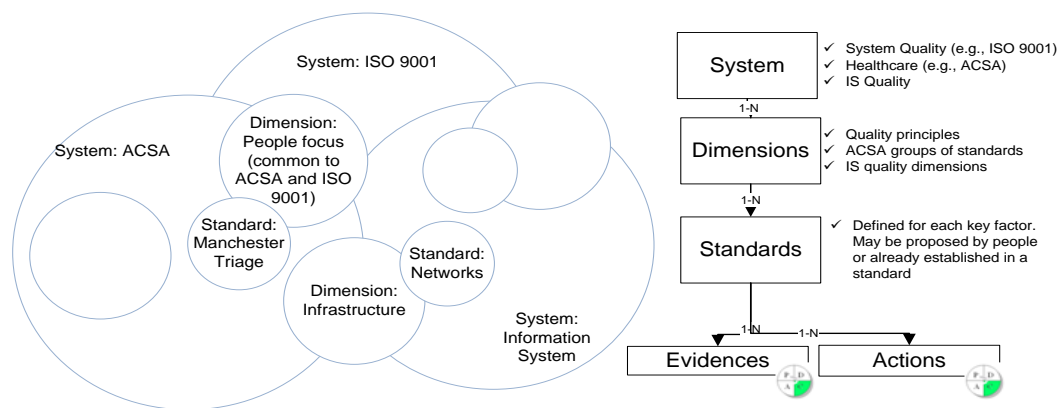


Fig. 7. Hospital multiverse – a global entanglement

Figure 7 represents the different systems that coexist in the organizational quality context. After identifying the systems, it is possible to describe each dimension (in our case, for ISO 9001 we used the standard principles, for ACSA we used the accreditation groups, and for IS we used the quality the dimensions suggested by [31]). It is also possible to merge specific dimensions, for example, “people focus” in ISO 9001 and “the person, central to the health system” in ACSA. Next, we identify the standards that are necessary to comply with for each dimension (checklist items). For each standard, the organization must present evidences and actions, evaluated according to the PDCA, as suggested by ISO 9001 and ACSA [1, 20].

4.5. Evaluating and Summing Up

The ISO₂ approach provided initial guidance for our research; however, it was developed with just ISO 9001 in mind. We introduced changes due to multiple realities in the healthcare setting. We used the original ISO₂ artifacts and identified potential new ones (dashboard, gap charts, multiverse representation), extending the approach for healthcare and multiple quality standards. Over several meetings, we could discuss the gaps in the hospital IS and QMS: (1) regulatory gaps, for example, between overall hospital principles and quality model requirements that should be adopted in each service; (2) design-practice gaps [17] between IT, process documentation (procedures), and daily practice, and (3) functional gaps between the perspectives of doctors and nurses, for example, in the lack of integration between IT application in pediatric internment.

The hospital professionals that participated in our study pointed out the contrast of evaluations as strength when compared to a consensus evaluation. According to the quality manager, contrasting reinforces the continuous reflection and learning: On the one hand, ISD and quality teams understand service specificities; on the other hand, hospital staff internalizes quality principles and participates in systems requirements identification.

The purpose of the hospital was to identify actions that could improve IS quality, ISO 9001 certification, and ACSA accreditation. Consequently, we did not address sequent steps of ISO₂ such as IT sourcing (beyond step 4). Interviews and checklists are less structured when compared to other tools available for eliciting eHealth requirements. Nevertheless, hospital managers stated that they discovered a new improvement approach that is accessible to both, healthcare and technical staff, deciding to adopt and expand it to all their services. They also told us that ISO₂ brings a new breath to development because it is not prescriptive, as it happens with accreditation models checklists. ISO₂ defies eHealth experts and healthcare professionals to create tailored checklists, aligned with top-level policies, but flexible to be adapted and evolve.

5. Conclusions, Limitations, and Future Work

We have presented an approach to synergistically develop the IS and the QMS in hospitals, accessible to all the staff, challenging users to jointly reflect about their multiple realities, learn from parallel realities of other services, and create bridges that improve hospital communication. The approach uses simple artifacts, built around the core quality principles that guide the entire hospital existence. We have used the multiverse metaphor to represent this vision for healthcare. Moreover, it is recognized that each service has differences in their practice, and that every person can participate in IS/QMS development, according to their own perspective of reality.

Naturally, this research has limitations. First, the scope of quality is restricted to ISO 9001 and ACSA. Second, in spite of the extensive documentation that we studied and the number of project participants (over 150), we only addressed two services of the hospital. Third, the hospital did not have a quality audit during our research, so we could not gather external opinion from quality auditors and assessors. Forth, the positive results must be carefully evaluated due to the Hawthorn effect, warning that the observed participants behavior could be *“related only to the special social situation and social treatment they received”* [16].

That said, our study also raised new avenues for future research. First, there is an opportunity to create tools for visualization of synergies between the IS and the QMS, comparing different hospital services, improving healthcare disclosure [2]. Second, our research suggests a solution to integrate complementary quality models [18], and other standards can be included in the future, for example EFQM. Third, we proposed new conceptual artifacts (dashboard and multiverse map) that could benefit from a support tool for practitioners. Forth, subsequent CAR cycles can address a more detailed level of eHealth processes. Fifth, there is an opportunity to study the multiverse theory in IS. Several authors enriched IS history with theories from other fields, for example biology [9]. In this case we

propose to address a stimulating theoretical proposal from physics [13]. These are the challenges to tackle in our next action research cycle.

Acknowledgements

This work has been partially funded by the ICIS project CENTRO-07-0224-FEDER-002003. The authors are indebted to Alexandra Ângelo and Sérgio Bugalho for their contribution to this research.

References

- [1] Almuedo-Paz, A., Núñez-García, D., Reyes-Alcázar, V., and Torres-Olivera, A. 2012. "The ACSA Accreditation Model: Self-Assessment as a Quality Improvement Tool," in Savsar M (ed) *Quality Assurance and Management: InTech*, pp 289–314.
- [2] Angst, C., Agarwal, R., Gao, G., Khuntia, J., and McCullough, J. S. 2014. "Information technology and voluntary quality disclosure by hospitals," *Decision Support Systems* (57:1), pp. 367–375.
- [3] Au, G., and Choi, I. 1999. "Facilitating implementation of total quality management through information technology," *Information management* (36:6), pp. 287–299.
- [4] Avison, D., and Fitzgerald, G. 2003. "Where now for development methodologies?," *Communications of the ACM* (46:1), pp. 78–82.
- [5] Barata, J., and Cunha, P. R. 2014. "ISO2: A New Breath for the Joint Development of IS and ISO 9001 Management Systems," in Escalona M, Aragón G, Linger H, et al. (eds) *Information Systems Development: Improving Enterprise Communication (Proceedings of the 22nd ISD)*: Springer, pp 499–510.
- [6] Barata, J., and Cunha, P. R. 2014. "Towards a Business Process Quality Culture: From High-Level Guidelines to Grassroots Actions," *Proceedings of the 23rd International Conference on Information Systems Development (ISD)*.
- [7] Barata, J., Cunha, P. R., and Costa, C. C. 2013. "Developing an IS Quality Culture with ISO 9001: Hopefully, a Never Ending Story," *Proceedings of the 24th Australasian Conference on Information Systems (ACIS)*.
- [8] Baskerville, R. 1999. "Investigating information systems with action research," *Communications of the Association for Information Systems* (2:3), pp. 1–32.
- [9] Benbya, H., and McKelvey, B. 2006. "Using coevolutionary and complexity theories to improve IS alignment: a multi-level approach," *Journal of Information Technology* (21:4), pp. 284–298.
- [10] Curtis, B., Krasner, H., and Iscoe, N. 1988. "A field study of the software design process for large systems," *Communications of the ACM* (31:11), pp. 1268–1287.
- [11] Davison, R., Martinsons, M. G., and Kock, N. 2004. "Principles of canonical action research," *Information Systems Journal* (14:1), pp. 65–86.
- [12] Deliç, M., Radlovački, V., Kamberović, B., Vulcanović, S., and Hadžistević, M. 2014. "Exploring the impact of quality management and application of information technologies on organisational performance – the case of Serbia and the wider region," *Total Quality Management & Business Excellence* (25:7-8), pp. 776–789.
- [13] Deutsch, D. 2002. "The structure of the multiverse," *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* (458:2028), pp. 2911–2923.
- [14] Domínguez-Mayo, F. J., Escalona, M. J., Mejías, M., Ross, M., and Staples, G. 2012. "A quality management based on the Quality Model life cycle," *Computer Standards & Interfaces* (34:4), pp. 396–412.
- [15] Freixo, J., and Rocha, Á. 2015. "QUALITUS: An Integrated Information Architecture for the Quality Management System of Hospitals," in A. Rocha et al. (eds.) *New Contributions in Information Systems and Technologies, Advances in Intelligent Systems and Computing*: Springer, pp 285–297.

- [16] French, J. R. P. 1950. "Field Experiments: Changing Group Productivity," in Miller JG (ed) *Experiments in Social Process: A Symposium on Social Psychology*: McGraw-Hill, pp 81–96.
- [17] Heeks, R. 2006. "Health information systems: Failure, success and improvisation," *International Journal of Medical Informatics* (75:2), pp. 125–137.
- [18] Hu, Y., and Xue, L. 2014. "Research on Quality Management System Design for Hospitals," *Proceedings of the 11th International Conference on Service Systems and Service Management (ICSSSM)* , pp. 1–5.
- [19] IAF. 2015. *Transition Planning Guidance for ISO 9001:2015*. ISO/TC 176/SC2: International Accreditation Forum.
- [20] ISO. 2008. *ISO 9001 Quality management system – Requirements*: International Organization for Standardization, Geneva.
- [21] Jørgensen, T. H., Remmen, A., and Mellado, M. D. 2006. "Integrated management systems – three different levels of integration," *Journal of Cleaner Production* (14:8), pp. 713–722.
- [22] Kautz, K., Madsen, S., and Nørbjerg, J. 2007. "Persistent problems and practices in information systems development," *Information Systems Journal* (17:3), pp. 217–239.
- [23] Kostagiolas, P. 2006. "Information Services for Supporting Quality Management in Healthcare," *Journal On Information Technology In Healthcare* (4:3), pp. 137–146.
- [24] Lee, D. 2012. "Implementation of quality programs in health care organizations," *Service Business* (6:3), pp. 387–404.
- [25] Mosadeghrad, A. M. 2013. "Obstacles to TQM success in health care systems," *International Journal of Health Care Quality Assurance* (26:2), pp. 147–173.
- [26] Paul, R. J. 2007. "Challenges to information systems: time to change," *European Journal of Information Systems* (16:3), pp. 193–195.
- [27] Pérez-Aróstegui, M. N., Bustinza-Sánchez, F., and Barrales-Molina, V. 2015. "Exploring the relationship between information technology competence and quality management," *BRQ Business Research Quarterly* (18:1), pp. 4–17.
- [28] Rakhmawati, T., Sumaedi, S., and Astrini, N. J. 2014. "ISO 9001 in health service sector: a review and future research proposal," *International Journal of Quality and Service Sciences* (6:1), pp. 17 – 29.
- [29] Rodríguez-Cerrillo, M., Fernández-Díaz, E., Iñurrieta-Romero, A., and Poza-Montoro, A. 2012. "Implementation of a quality management system according to 9001 standard in a hospital in the home unit: changes and achievements.," *International journal of health care quality assurance* (25:6), pp. 498–508.
- [30] Sampaio, P., Saraiva, P., and Domingues, P. 2013. "Management systems: integration or addition?," *International Journal of Quality & Reliability Management* (29:4), pp. 402 – 424.
- [31] Stylianou, A. C., and Kumar, R. L. 2000. "An integrative framework for IS quality management," *Communications of the ACM* (43:9), pp. 99–104.
- [32] Susman, G. I., and Evered, R. D. 1978. "An Assessment of the Scientific Merits of Action Research," *Administrative Science Quarterly* (23:4), pp. 582–603.
- [33] Wilson, L. 2000. "'Quality is everyone's business' why this approach will not work in hospitals," *Journal of Quality in Clinical Practice* (20:4), pp. 131–135.
- [34] Yeh, T-M., and Lai, H-P. 2015. "Evaluating the effectiveness of implementing quality management practices in the medical industry," *The journal of nutrition, health & aging* (19:1), pp. 102–12.