

Comprehensive Evaluation of Radiation Oncology Information Systems (ROIS)

Introduction: The radiation oncology field has recently experienced a massive increase in sophisticated technologies, radiation treatment delivery techniques and electronic information storage. In addition, the healthcare system calls for more efficient, effective and safer processes and treatments, providing high quality patient care at competitive cost. Given all these demands and the complexity of the radiation oncology field, it is becoming very challenging to maintain high standards of patient care and at the same time guarantee safety, robustness, interoperability, reliability, accuracy and efficiency without the contribution of information systems (IS) and information technology (IT) solutions. Since their introduction in the 1970s as computerized record and verify systems, Radiation Oncology Information Systems (ROIS) have evolved to become the bridge between management of the information, technological innovations, patient treatment and high quality level of patient care¹. Successful implementation of ROIS depends greatly on a clear understanding of the site-specific clinical processes and IS/IT infrastructure as well as the capacity of ROIS to match the constraints and clinical practice of a particular institution. Moreover, Ammenwerth *et al.*² have shown that the evaluation of any IT/IS solution is not just the evaluation of a single product alone, but the evaluation of the product in the environment where it will be used. The aim of this work is to use current knowledge in the area of health information systems evaluation and develop a comprehensive assessment methodology for ROIS.

Methods and Materials: The foundation of our methodology is based in the identification and understanding of the interlinked components of the modern radiation oncology practice (Fig.1). These components were defined as: Peopleware³, Clinical Processes and Software-Hardware. Based upon these components, three major areas were defined for the development of the assessment methodology: Clinical Processes (CP), Information Management (IM) and Technological Innovations Integration (TII). The CP included all tasks and activities related to patient management and treatment from start to finish. The CP were classified using some of the definitions proposed by Brooks *et al.*⁴. The IM was associated with each of the IS/IT infrastructure components and processes corresponding to the patient and treatment information management and included the following categories: database management, long-term archiving, application availability, customer support, system integration, IS/IT infrastructure connectivity and data conversion. The TII covered the ability of the ROIS to integrate with current and future technological advances. For the TII, four technologies were evaluated: Portal Dosimetry, MV and kV image guidance and Cone Beam CT. Additionally, a team of experts (*Peopleware*) was created representing the different areas of the radiation oncology department. The team included: physicians, physicists, dosimetrists, therapists, administrative and IS staff. The responsibilities of the team members were to define and characterize all clinical processes and corresponding tasks and activities as well as to map the department's IS/IT infrastructure. Subsequently, the team members also evaluated and provided experiential feedback through out the assessment process.

Two methods were used to characterize the site-specific practice and environment: IS/IT Infrastructure maps and Process Flow maps. The IS/IT Infrastructure maps provided a comprehensive layout of all relevant internal/institutional systems and corresponding department components which provide the backbone for information communications. The Process Flow maps provided a detailed description of each of the clinical processes and corresponding information flow within the department from the initial patient encounter to the end of the corresponding treatment. Figures 2 and 3 shows the templates proposed for the infrastructure and process flow maps.

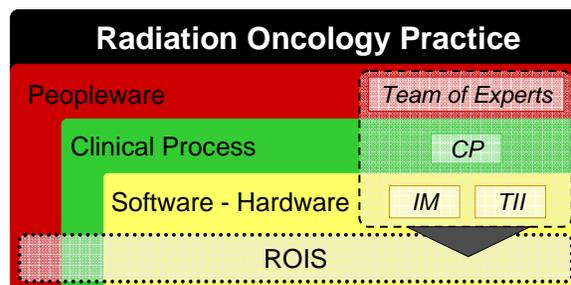


Figure 1. Modern Radiation Oncology Classification Model

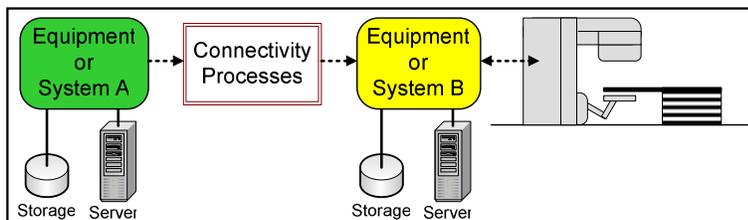


Figure 2. IS/IT Infrastructure Map Template

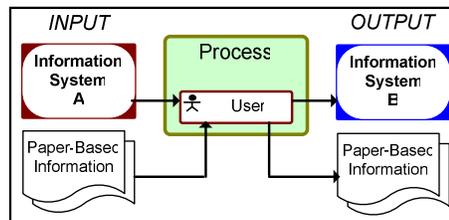


Figure 3. Process Flow Map Template

Two ROIS configurations were chosen to be studied: clinical multi-vendor system (Multi-ACCESSTM - VARISTM) and a test single-vendor system (ARIATM) (*Software-Hardware*). The test single-vendor system was configured to allow the team members to perform all tasks, activities and processes in our current clinical practice from the initial consult of the patient to the treatment delivery. As part of the configuration, all tools provided by the test single-vendor ROIS were identified and mapped to the clinical processes.

The three main areas (CP, IM and TII) were analysed using a survey instrument. The purpose of the survey is to map two independent parameters that together will define the level of integration between the ROIS and the clinical environment. The first parameter is Importance for Patient Care (IPC). The IPC measures the importance of each assessment variable as it relates to the quality, accuracy and safety of the patient treatment. The second parameter is the Performance Index (PI). This parameter represents the user's perception of the ROIS performance when using the tools provided by the ROIS. The PI is intended to be a surrogate for measuring the level of integration between the ROIS and the site-specific clinical practice, needs and infrastructure. The survey was designed to follow the tasks, activities and processes already classified in the CP, IM and TII. Each task, activity and process was used to create a single survey question and became an assessment variable. An IPC weighting factor and PI were assigned by the team members to each of the assessment variables based in their clinical experience. The data gathered from the survey for IPC and PI were tabulated and graphed to create the PI-IPC space. By defining acceptance thresholds in the graph, the PI-IPC space was divided into four regions: two Acceptance Regions (AR-I and AR-II) and two Rejection Regions (RR-I and RR-II). While scoring each of the survey questions, the team members were asked to provide suggestions and ideas on how to improve either the clinical process itself or the tool provided by the ROIS. This commentary, when added to the assessment scores, provides a complete picture of the strengths and weaknesses of the components of a given ROIS.

Results: Using the proposed IS/IT infrastructure map templates three primary infrastructure/dataflow scenarios were identified. The multi-vendor setup presented two scenarios that were classified as EXCI-IMPAC and 4DITC-IMPAC. The single-vendor setup was classified as 4DITC-VARIAN. Different scenarios were evaluated for potential interoperability problems and lack of functionality and connectivity. Potential problematic nodes in the information transfer flow were identified and documented. This section of the assessment methodology provides a deep understanding of the real causes of interoperability issues in the IS/IT infrastructure and presents information for both the institution and the ROIS developers to improve process/solutions.

Analysis of the PI-IPC space for both ROIS configurations showed above adequate performance based on the clinical processes and infrastructure of our department and our patient care standards. Despite this fact, several variables were found to poorly perform in areas deemed important for patient care (Fig. 3). Experiential feedback and the quantitative data from the surveys were used to develop a global report and a site-specific master priority list.

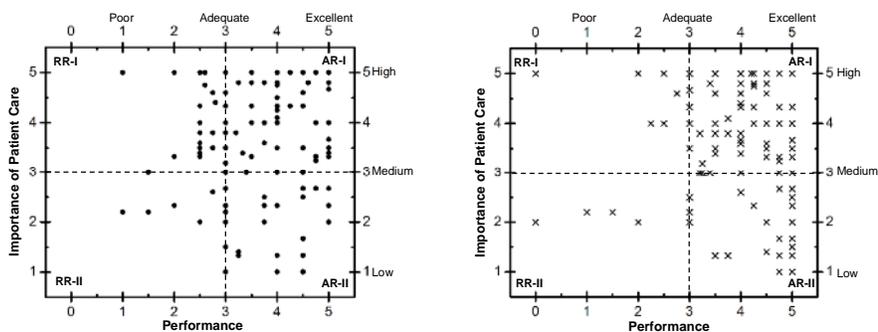


Figure 3. Plot of performance vs. patient care for the two evaluated ROIS

Conclusions: This work attempts to provide an objective tool to understand and analyse information flow and its compatibility with a given ROIS in a clinic specific patient care setting. Mapping provides insight into process communication, interoperability and efficiency. The hierarchy and importance of various characteristics are customizable to a given clinical practice and thus allow the tool's broad applicability. Proper assessment of information flow and matching to an ROIS will provide a more efficient and more effective care delivery setting.

¹Herman, M.G., Williams, A.L., and Dicello, J.F. "Management of Information in Radiation Oncology: An Integrated System for Scheduling, Treatment, Billing and Verification." *Sem in Radiat. Oncol.* 1997;7:58-67.

²Ammenwerth E, Graber S, Herrmann G, et al. "Evaluation of health information systems-problems and challenges". *International Journal of Medical Informatics* 2003;71:125-135.

³Lorenzi N.M, and Riley R. T *Organizational Aspects of Health Informatics: Managing Technological Change*, New York, Spring-Verlag, 1995, pp 11-13.

⁴Brooks, K.W., Fox T.H. and Davis L.W. "Advanced Therapy Information Management Systems: An Oncology Information System RFP Toolkit." In *Imaging in Radiation Therapy* J.D. Hazel and A.L. Boyer (Eds.) AAPM Monograph No. 24, 1998