Potential interoperability problems facing multi-site radiation oncology centers in The Netherlands

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Abstract Aim: To identify potential interoperability problems facing multi-site Radiation Oncology (RO) departments in the Netherlands and solutions for unambiguous multi-system workflows. Specific challenges confronting the RO department of VUmc (RO-VUmc), which is soon to open a satellite department, were characterized. Methods: A nationwide questionnaire survey was conducted to identify possible interoperability problems and solutions. Further detailed information was obtained by in-depth interviews at 3 Dutch RO institutes that already operate in more than one site. Results: The survey had a 100% response rate (n=21). Altogether 95 interoperability problems were described. Most reported problems were on a strategic and semantic level. The majority were DICOM(-RT) and HL7 related (n=65), primarily between treatment planning and verification systems or between departmental and hospital systems. Seven were identified as being relevant for RO-VUmc. Departments have overcome interoperability problems with their own, or with tailor-made vendor solutions. There was little knowledge about or utilization of solutions developed by Integrating the Healthcare Enterpris e Radiation Oncology (IHE-RO). Conclusions: Although interoperability problems are still common, solutions have been identified. Awareness of IHE-RO needs to be raised. No major new interoperability problems are predicted as RO-VUmc develops into a multi-site department.

1. Introduction

A general definition of interoperability is “The ability of systems and organizations to effectively collaborate”. Systems can interact with each other at different levels, each of which may have its own specific requirements [1]. Interoperability problems can occur in three areas:

(1) Technical interoperability - required so that systems can exchange data.
(2) Tactical interoperability - requires an unambiguous message structure.
(3) Semantic interoperability - requires correct interpretation of the delivered information.

In the past most Radiation Oncology (RO) departments used equipment from a single vendor, and were based at one location with a limited, mostly non-electronic, data stream. Due to the increasing use of medical imaging techniques and the rise of interdisciplinary cancer care, the information flow has increased significantly [2] and is no longer limited to the department itself. A substantial data stream comes from other departments in the hospital (intramural) and from departments outside the...
hospital (extramural). In addition, communication has become not only faster, but also more complex with less human intervention.

Despite an increasing number of medical standards such as DICOM and HL7, successful operational integration of medical information systems still cannot be guaranteed nor can interoperability be ensured [1-6]. It is suggested [7] that interoperability problems in health care are not specific for the present time, but their impact has increased. To improve interoperability the HIMSS (Healthcare Information and Management Systems Society) and the RSNA (Radiological Society of North America) started a joint initiative called ‘Integrating the Healthcare Enterprise’ (IHE) in 1998. This is a partnership between providers and professionals. IHE promotes the use of established standards rather than developing them [8, 9] and defines a technical framework for each field of work. The framework consists of integration profiles that accurately describe the processes and tasks in that field. In addition, an information model is developed which describes the messages that need to be exchanged between different systems in order to successfully complete a given process [8]. Initially, IHE focused on diagnostic radiology alone but nowadays 9 work fields are covered, including radiation oncology (IHE-RO).

In December 2012 the VU University medical center (VUmc) in Amsterdam, The Netherlands opened its first satellite RO facility located about 50 km away in a general hospital. In January 2011 we began a study to identify potential interoperability issues in the RO domain associated with the new configuration of the department. The aims of this study were (1) to identify interoperability problems at multi-site RO departments in the Netherlands, and (2) to identify possible interoperability problems at the VUmc RO department specifically in order to enable unambiguous workflows in the multi-center situation.

2. Methods
An online nationwide questionnaire survey was conducted to identify possible interoperability problems and solutions that had been applied. The questionnaire consisted of 52 questions in three parts. The first part focused on the equipment and the information systems used in any given department. The second part of the questionnaire addressed interoperability issues that the departments had experienced. The strategies used to tackle interoperability problems were subject of the third part of the questionnaire. In the case of initial non-response, this was followed up by mails and telephone calls. A pilot was conducted at two departments before the optimized questionnaire was sent to all Dutch departments (n=21)

Further detailed information was obtained by in-depth semi-structured interviews in 3 Dutch RO institutes already operating as a multi-site department (n=2) or with advanced plans for a satellite department (n=1).

3. Results
The final response to the survey was 100% (n=21). The first part of the survey, which describes the complexity of the department, confirmed that departments use a variety of information systems. None of the departments exclusively used systems from a single vendor. Almost all departments (19) also used software that had been developed in-house (e.g. e-chart, independent dose-verification) and 17 RO departments shared imaging modalities with other departments in their facility, e.g. departments of radiology and nuclear medicine.

Pooled results from the second part of the survey identified 95 interoperability issues, of which 65 (69%) were DICOM or HL7 related (Table 1). A substantial number of these (n=28, 29%) were DICOM-RT related and frequently hindered communication between the treatment planning system (TPS) and the record-and-verify (R&V) system at the radiotherapy treatment machines. Typical
examples included different interpretation of DICOM tags and the incomplete transfer of treatment data between the TPS and R&V system. To solve such issues four departments had developed their own applications. Intramural issues (n=74) were mainly related to DICOM (n=47) and HL7 (n=12) interoperability problems and predominantly hampered workflow applications and the Hospital Information System (HIS). To overcome these issues data were often manually copied from one system to another. Two departments indicated that these issues were caused by not permitting the import of patient data from the PACS or HIS of other hospitals for safety or legal reasons. Consequently, these data need to be transferred on CD or manually. Similar problems, causes and consequences were observed at the extramural level.

**Table 1.** The interoperability problems reported by the 21 Dutch Radiation Oncology departments categorized to the standard they were related to.

|                  | Within Dept | Intramural | Extramural | Total |
|------------------|-------------|------------|------------|-------|
| DICOM            | 12          | 7          | 5          | 24    |
| DICOM-RT         | 26          | 2          | 0          | 28    |
| HL-7             | 2           | 10         | 2          | 14    |
| Remaining        | 7           | 8          | 14         | 29    |
| Total            | 47          | 27         | 21         | 95    |

The third and last part of the survey identified which strategies were being used to prevent interoperability problems and demonstrated a department’s acquaintance with the work and role of IHE-RO (Figure 1). Only slightly more than a quarter of the departments (n=6) negotiated solutions with the vendor or with third parties; solutions were always dedicated to the local specific situation rather than generic ones, i.e. applicable for similar situations. About 50 % of the departments solved problems on their own (n=10), some of them even developed their own applications if necessary (n=4). Only 2 departments prevented problems by reducing data-transfer between systems. The remaining three departments opted for a one-vendor solution (n=1) to prevent interoperability problems or accepted the existence of interoperability problems (n=2). Knowledge of IHE-RO was limited in all departments; Although 15 of the respondents were aware of its existence only 1 department had implemented a single IHE-RO profile; the reason was that own solutions were favored over the IHE-RO solution.

![Figure 1: The strategies used by the 21 Dutch Radiation Oncology departments to prevent or overcome interoperability issues.](image-url)
The further in-depth interviews confirmed the results described above, and with regard to multi-center institutions, three points of interest were highlighted. First, the use of paper charts can sometimes lead to urgent and immediate problems (e.g. chart is not present on the right location or the chart is missing); for this reason 2 out of the 3 departments worked in a paperless environment and the third one had advanced plans to become paperless. Second, concerning the availability of various specialists: all 3 departments had one or more physicians at the satellite location. Only one department also had a physicist available on location and the other two used ‘cockpit’ approaches, meaning that information on the satellite unit’s consoles could be viewed and (if necessary) controlled from the home-location. Third, all 3 departments had enlarged their computer-network to the satellite location as a bulge and mirrored networks were installed to ensure continuity in case of failures, e.g. network loss or unplanned downtime.

4. Discussion

This study investigated interoperability problems in RO departments in The Netherlands and how they were being addressed. Specifically, the situation in our own department was investigated in order to prevent possible interoperability problems in a multi-site environment.

Although technical interoperability problems are rare, the real challenges are to acquire and maintain interoperability on both a tactical and semantic level. Interoperability problems within a department predominantly occurred between the treatment planning and the record-and-verify systems. Intramural interoperability problems mainly took place between the workflow applications and the HIS, and could significantly increase the workload if data had been manually copied. Most of these problems were DICOM and HL7-related, some were due to institutional safety policies. Similar extramural interoperability problems occurred mainly because of financial and legal reasons.

The current freedom of choice in implementing standards is a weak point because it can lead to interoperability problems. This will only be solved by consensus. Naturally, a balance between flexibility and rigidity is essential for consensus; on the one hand, a standard which leaves too much room for interpretation still risks producing interoperability problems. On the other hand, the use of new technological developments may be hindered if these are only allowed after the adoption of standards. Therefore interoperability is a long-term goal, requiring the continuous effort of all parties to reach a detailed consensus on how standards should be applied.

The IHE could play a role in radiation oncology in The Netherlands. Their workgroups include both users and vendors, which is necessary for wider acceptance. However, users in The Netherlands are insufficiently aware of IHE procedures and how they can enhance interoperability. A shared initiative from the already existing Dutch board “Information Technology (IT) in RO” could possibly give new input to the IHE-RO group in the development of Integration Profiles. Additionally the government could contribute by creating the proper preconditions for a necessary legal framework concerning safety and privacy at an extramural level.

5. Conclusions

An interoperability study, based on both a national survey and in-depth interviews with selected departments, was conducted with the participation of all Dutch radiation oncology departments. We showed that

(1) Interoperability problems on a technical level are rare and mainly occur between the TPS and the R&V systems within a department, or between RO-dedicated systems and the HIS on an intramural level;
(2) Only a few of the identified problems in a national survey are relevant for our own department’s growth towards a multi-site center;
The majority of the identified interoperability issues could be solved by already existing IHE-RO profiles, or profiles that are being developed.

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