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THE AUTOMATIZED WORKFLOW OF A RADIATION ONCOLOGY DEPARTMENT: A COMPLETE INTEGRATION OF THE ONCOLOGY INFORMATION SYSTEM MOSAIQ WITH HOSPITAL INFORMATION SYSTEM

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Abstract – *Objective:* *To fully integrate the OIS (MOSAIQ by Elekta) and the Hospital Information System (HIS) to increase efficiency, quality, and safety of care and to streamline clinical workflows and processes.*

Materials and Methods: *More than 25 dedicated staff members are currently working at the Radiotherapy Unit of our Institute and treat approximately 700 patients per year with two Elekta linear accelerators. Within a radiation treatment, there is a series of clinical and organizational steps that it is indispensable to do to avoid errors or excessive resource consumption.*

Our experience has led to the creation of structured workflows to overcome these critical issues through the optimization and integration of HIS and OIS, respectively our hospital and our Radiotherapy Unit data management systems.

Results: *Through the integration of the main management programs available and the creation of standardized therapeutic paths based on logistical and clinical needs, we managed to optimize both quality of care and accounting services provided.*

Conclusions: *The integration of different operating systems and the definition of standardized steps within the workflow has led to the abolition of unnecessary operations, making it easier to manage patients' care and prescription accounting. Furthermore, clinical records have become more readily and accessible by health care providers of our unit. All this translates into a decreased risk of misinformation, or time loss due to bureaucratic and organizational issues, therefore, allowing a significant increase in staff efficiency.*

KEYWORDS: *Radiation workflow, Oncology information system, Integration, Hospital information system.*

ABBREVIATIONS: *OIS, oncology information system; HIS, hospital information system; CT, computerized tomography; RT, radiotherapy.*

INTRODUCTION

Radiotherapy is a form of cancer treatment that requires several preparatory steps consisting of medical evaluations, imaging, treatment planning, and delivery. All these activities also need administrative time for physicians to schedule, record, and report. Woolhander et al[1] highlighted that a physician spends on average about 1.7 hours each day on non-patient-related administrative work (one-sixth

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of their total working hours). This physician's time, not patient-directed, in a public service provider, is necessary to measure the performance of health service and to support planning and management control. If this is true in all medical practice, it is especially true in radiotherapy where resources are expensive and limited in capacity. It is essential to highlight that approximately 50% of all cancer patients need radiation therapy during their course of illness[2]. Because RT contributes towards 40% of curative treatment for cancer, it is necessary to ensure timely delivery of radiation therapy for each patient to optimize clinical outcome[3]. Since in radiotherapy a workflow exists defined as a sequence of physical and mental tasks performed by various people within and between work environments [4], it is necessary to manage this workflow to do the right thing at the right time. Indeed, the most important consequence of not using a workflow system/strategy/approach is a lost opportunity for the patient. Just think that lengthening the waiting time for a non-clinical problem could determine a failure of local control of the disease and this loss could decrease survival in some clinical situations.

Another important point is the prevention of treatment errors in clinical practice. A study by Marks et al[5] showed that errors may occur at any point in the continuum of a multistep treatment process. Many of these errors may be detectable and preventable before treatment.

All these considerations seem to suggest the introduction of an automation of the radiation workflow. As defined by the International Society of Automation, "the creation and application of technology to monitor and control the delivery of products and services"[6] is crucial in radiotherapy to reduce the burden on providers and staff, improve quality and efficiency, and deliver better value to patients and caregivers[7, 8].

MATERIALS AND METHODS

AULSS 9 Radiation Oncology Department treats approximately 700 patients yearly with 2 Elekta linear accelerators and 25 staff members. The department operates on the MOSAIQ Radiation Oncology platform with a treatment planning system Philips Pinnacle Version 16. With the upgrade of MOSAIQ to version 2.64 in May 2020, the multidisciplinary quality improvement team initiated a series of meetings to structure a departmental quality improvement. Firstly, the radiation working process needed to be designed. Secondly, we had to track our working process using the quality checklist (QCL) function. A MOSAIQ user can create a QCL item for a patient, and it is possible to assignee it to another user, instructing them regarding what and when tasks need to be completed: consultation, CT- simulation, treatment planning, and treatment initiation until completion, follow-up. The use of Quality Check List (QCL) allows us that no critical procedures go undocumented. Another important step was the translation of our workflow into a series of coded actions within the software OIS MOSAIQ. Finally, there was the development of a middleware to have liaising OIS and HIS.

RESULTS

Define the STEPS

Multidisciplinary teams were created to review the patient care workflow in our department and construct process maps to chart the events from patient consultation to treatment completion and follow-up. The RT treatment process starts with a referral to the radiation oncologist. The patients are seen during the first consultation, filling the radiation oncologist record. The patients that need a radiation approach are included in the pre-treatment workflow where there are the necessary steps before the radiation treatment starts. The pre-treatment workflow includes imaging (preparation of CT imaging, rigid or deformable registration with CT, MRI, and PET-CT), contouring (the tumor and organs-at-risk), treatment planning, and verifying. These actions normally end with the first irradiation scheduling which is usually set immediately after the first consultation.

The first STEP: referral

To ensure that there can be an order in the radiation workflow, it is essential primarily to manage the patient information correctly. The patient registry is obtained by HIS inserting a radiation oncologist's appointment, automatically passing the first name, last name, birth date, birthplace, NHS ID, and tax code. Administrative staff will enter the name of consulting RO and referring physician (medical oncology or surgeons). Patient consultation is booked through HIS and the demographic information is sent to the OIS and stored in its archive/server (Figure 1). This first procedure reduces the probabilities of repeated entry data and mistakes. Changes in the patient's data would trigger an HL7 update to be sent from HIS to OIS, keeping both HIS' and OIS' data in sync. Possible changes in the patient's info in HIS have been reflected automatically in OIS.

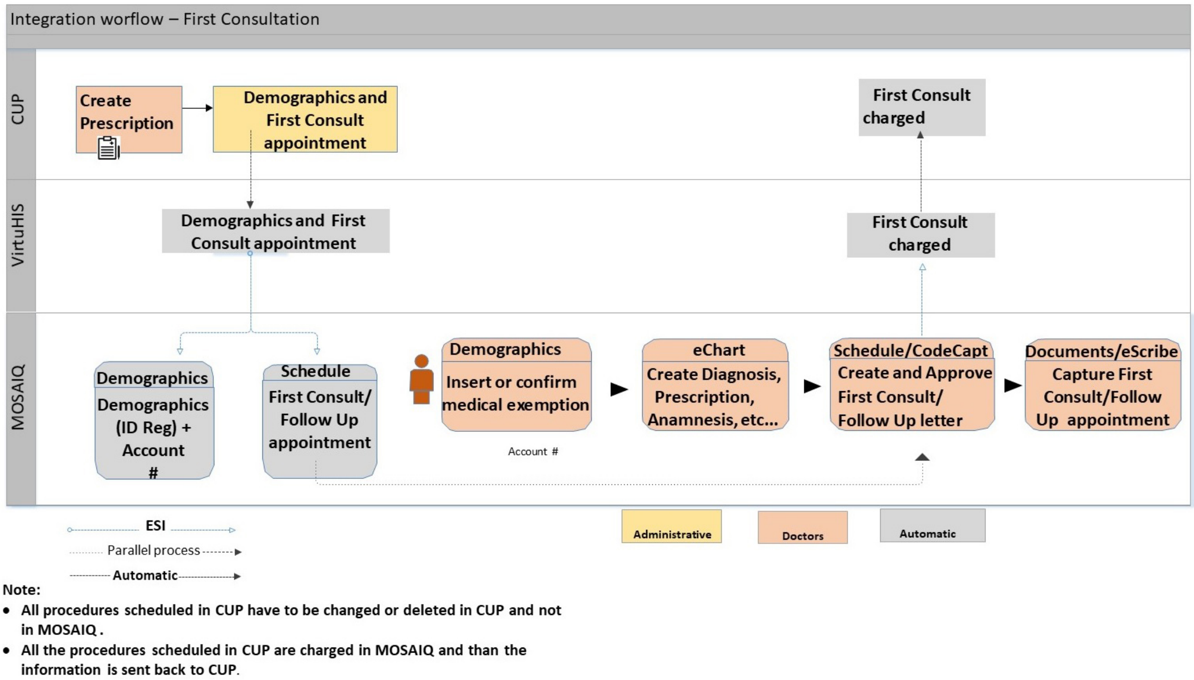

Figure 1. Integration workflow for the first consultation.

The second STEP: Patient Assessment

The availability of information is crucial for quality treatment care. During the patient's assessment, only radiation oncologists (RO) can enter data on the patient profile.

Patient history and examination findings are entered in 5 subfolders, of which only 4 are used in this step (Figure 2). The first, called "anamnesi" contains the case history; all information obtained by a RO is useful in providing radiation and medical care. The second, "es. Obiettivo", contains examination findings such as general condition, performance, and information regarding the primary/tumor, lymph node, and metastasis. The third subfolder "dia+pat" contains imaging history (CT, MRI, CT-PET) with a summary of radiological reports and pathological summary of disease with staging. The fourth subfolder contains information about the radiation program as treatment intent (curative, adjuvant, or palliative). All documents are scanned and saved as PDFs in the patient's document chart. In D&I screen, RO realizes a quick visual summary of the patient's case, a very concise and easy-to-understand clinical history. In MOSAIQ, this view is built from the entries placed into four screens in the order – Diagnosis > Protocol > Prescription > Order Set. The result is a visual clinical record.

The RO generates a QCL set requiring only two task sets: the first is CT simulation data assigned to the radiographer/technician CT-staff and the second is assigned to the OIS manager with expected radiation start-up data and machine. Subsequently, the OIS manager will generate a contour task for the radiation oncologist and a planning task for the medical physicist. Normally we apply a pull strategy: the date for the start of treatment is set right after consultation and the scheduling of pre-treatment workflow is performed in a "backward" manner. The pre-treatment activities need to be given enough time to be completed before the pre-scheduled starting date to avoid linac sessions re-books.

Figure 2. The screen of MOSAIQ to introduce clinical assessment.

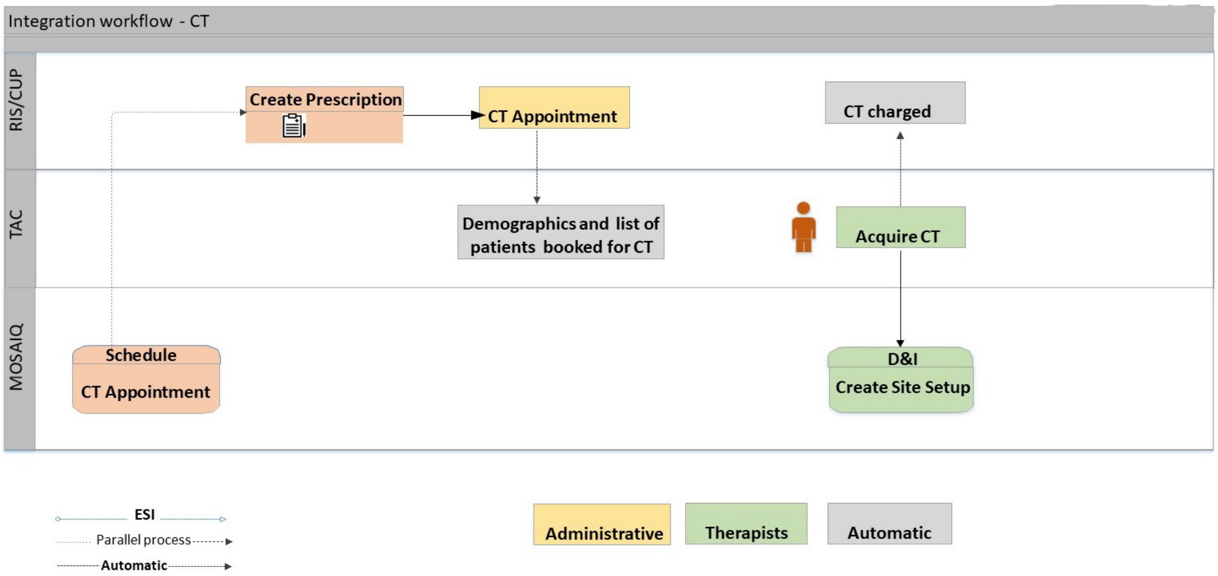

Figure 3. Integration workflow for the CT plan acquisition.

A template for patient assessment was projected as a document skeleton that uses "placeholders" to show where specific content (written in 4 subfolders) should be inserted. In this template, the CT simulator data automatically is inserted from the CT calendar.

The third STEP: Treatment planning

Treatment planning begins with positioning the patient on the CT scan. There is a need to position the patient in a way that meets a minimum need to ensure feasibility but also to ensure consistency of setup during the RT course. The integration previews a passage of information from the OIS through the HIS (Figure 3).

When the CT scans are acquired, the radiographer completes the QCL task, captures the CT code, and assigns the contouring QCL task to RO.

The next step in the process involves MRI and PET imaging registration to the planning CT and delineation of relevant organs and tissues as Clinical Target Volume (CTV) and Organ At Risk (OAR). The RO completes the QCL task and assigns the subsequent planning QCL task to medical physicists. The goal of the medical physicist, in this step, is to optimize the prescribed parameters with a treatment plan that is physically deliverable using the most suitable radiation techniques. Normally, more planning is calculated on the same CT image set, allowing qualitative and quantitative review of the dose level to the target structures as well as OAR structures. Obtaining these goals, the medical physicist completes his planning task and will assign the following task to RO (evaluation and approval). During the review step, RO will evaluate the dose distribution relative to the target and OAR and potential areas of over or under-coverage.

After the approval, the treatment plan (from the treatment planning system Philips Pinnacle) is converted to PDF files signed by the RO and stored in MOSAIQ under Diagnosis and Interventions. The medical physics (MP) assigns the QCL task to the OIS manager to program quality assurance (before patient treatment) and combines the correct CT, contouring, planning code, and captures them (Figure 4 non-bookable activities). OIS and MP ensure that the plan meets correct criteria using checklists and other quality-assurance tools. Finally, patients can be confirmed in linac scheduling normally driven by the starting date scheduled after the first consultation.

The fourth STEP: patient treatment

Before RT, imaging is acquired and analyzed online to modify the patient setup to target the tumor most accurately. The delivered dose and imaging are recorded automatically in MOSAIQ. The radiation technicians capture the codes of imaging and treatment (Figure 5). All other nursing and medical activities are managed according to Figure 6.

At the end of RT, RO visits the patient noting delivered total dose and fractionation dose in the patient history, 5 subfolder "follow-up". RO generates automatically a final medical report using the E-Scribe function and captures the visit code.

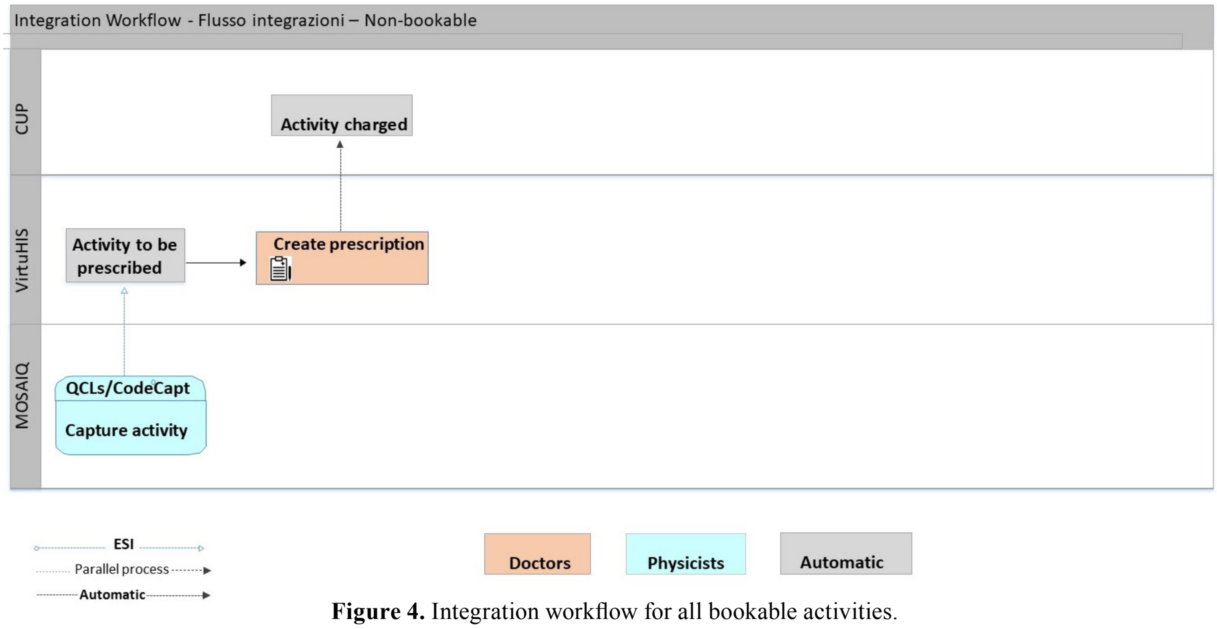

Figure 4. Integration workflow for all bookable activities.

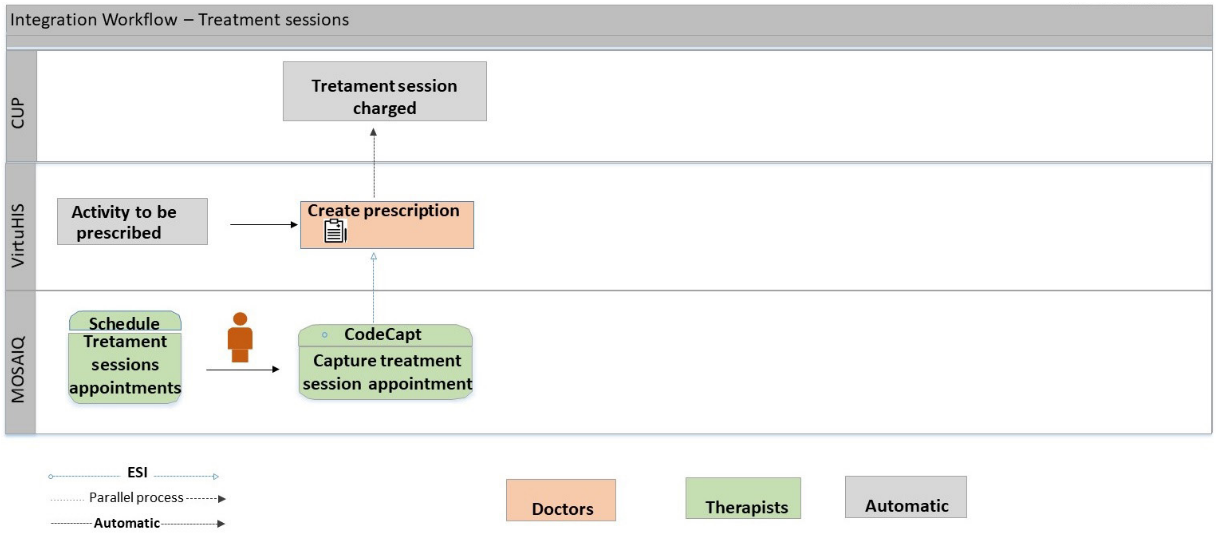

Figure 5. Integration workflow for treatment session.

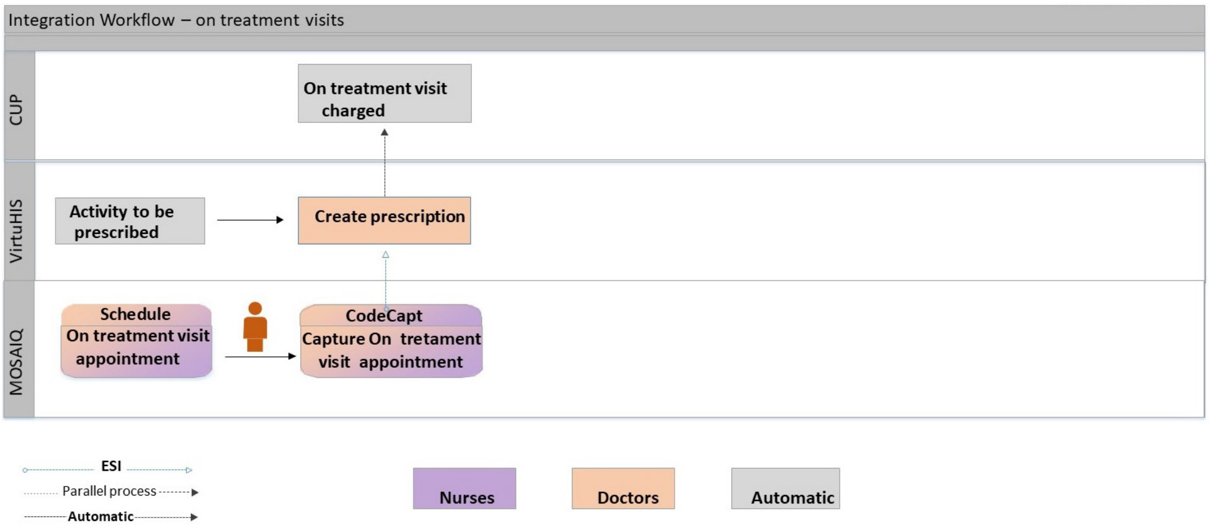

Figure 6. Integration workflow for on treatment visits.

The Follow-up

Radiation oncology patients receive close follow-up to recognize and manage the delayed effects of radiation (remaining RO responsible for toxicities). The visit appointment is scheduled directly by RO in the MOSAIQ follow-up calendar. RO evaluated the required instrumental testing procedures and examined the patient, noting in the patient history, 5 subfolder "follow-up". After, RO generates a follow-up letter using the E-Scribe function and captures the visit code.

Billing information

All RT procedures were archived in OIS and were captured by RO, MP, or technicians, and billing info was stored in the OIS archive. This information generates prescriptions in the hospital billing system through a middleware (VirtuHis software elaborated by Gmed ing. Silvio Taggi). Twice daily, ROs verify the captured billing info (in RT ambulatory/clinics, in CT-simulator, in planning, in treatments) and then will send these electronically as a financial transaction message. This mechanism would reduce errors and every record, which is captured for billing, would have automatic corresponding evidence for NHS.

CONCLUSIONS

Initially, the record and verify systems (R&Vs) were developed to reduce the risk of errors during radiotherapy. Before their introduction in clinical practice, the treatment parameters were set manually and could differ from the "prescribed" ones. These R&Vs can interface with imaging systems, treatment planning software, and treatment delivery systems. The R&V connects treatment-planning software with a delivery machine storing a complete set of information: patient's identification, prescription, treatment plan, and field parameters to allow the patient to be radio-treated. Evolving complexity of treatment planning has required the use of these R&V systems routinely. Then, R&Vs became a part of the control system of the delivery process linking to the treatment planning system. Today it is correct to call these medical devices radiotherapy information management systems linking Imaging Systems, Treatment Planning computers (TPS), and Treatment Delivery Systems (TDS). In fact, R&Vs have evolved in DBs that include not only treatment machine parameters, but also scheduling, images, assessments, document import and Health Level 7 (HL 7)[9].

We have developed an automatized workflow in RO integrating OIS and HIS, starting from the referral and arriving in follow-up. We have started with a MOSAIQ configuration to obtain the most efficient paperless model. Scheduling referral visits has become simple.

We have introduced clinical letters and files using the E-Scribe function eliminating redundant workflows, unnecessary work, and paper. With this approach, we process and visualize the information collected as patient custom properties and we store the data generated in real-time during the RT process for each patient. RO stored under "Chart" medical history, physical examination, histological examinations, imaging, and laboratory data and stored under "Diagnosis and Interventions" a very concise and easy-to-understand clinical history, including tumor stage, radiation therapy intent, and radiation total and daily prescribed dose. After treatment, RO registers, always in "Chart", the Follow-Up visits. Radiation technicians recorded in site setup under "Diagnosis and Interventions" information about the patient's positioning. Physicists stored in MOSAIQ under the "Diagnosis and Interventions" the treatment plan from Philips Pinnacle TPS and the pre-treatment test report and converted them to PDF files.

The flow of radiation therapy activities was managed through MOSAIQ, generating a task set "Quality Checklist (QCL)".

Normally, documents generated in radiotherapy are only located in IOS. The lack of shared information related to previous or ongoing radiation treatments and the possible presence of collateral radiation effects in a patient can be crucial when there is the urgent need to reach a correct diagnosis and treatment for the same patient in case of a sudden onset of other morbidities.

With integration, the patient's referral documents and treatment summary are sent to HIS by OIS.

All systems are accessible by any authenticated user. There is no possibility of accessing the data in this system by unauthorized personnel. The maintenance of this integration does not require large amounts of human resources. History of radiation treatment is stored uniquely and uniformly; in HIS it is possible to share RT information to reduce errors in patient diagnosis.

Finally, the middleware, functioning as a hidden translation layer, enables communication and data management between OIS and the hospital billing system. The administrative staff has to extract billing info from OIS, verify its accuracy, and enter it into the hospital's billing system. Introducing data manually can add errors in every step and thus resulting in inefficient. This may lead to a loss of income or may cause the National Health System (NHS) to deny the refund.

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