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RESULTS WP7

LIST OF DIGITAL SKILLS OF THERAPEUTIC RADIOGRAPHERS/RADIATION THERAPISTS: THEMATIC ANALYSIS OF THE LITERATURE REVIEW AND OF EUROPEAN SURVEY.

Ms Bárbara Barbosa, Ms Celeste Oliveira, Dr Jose G. Couto, Dr Ciara Hughes,
Dr Patricia McClure, Dr Sonya McFadden, Dr Isabel Bravo

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INTRODUCTION

This list of digital skills of Therapeutic Radiographers/ Radiation Therapists (TR/RTTs) across Europe was created by collating the skills of these professionals identified within existing literature. A qualitative document analysis of peer-reviewed (white) literature and other relevant documents (grey literature) was undertaken to gather the relevant digital skills for TR/RTTs. Other digital skills were also identified in current practice amongst TR/RTTs through a European survey. This list was created using a rigorous research methodology. Details on the methodology can be found in the following research publications:

B. Barbosa, I. Bravo, C. Oliveira, L. Antunes, J.G. Couto, S. McFadden, C. Hughes, P. McClure, A.G. Dias. Digital skills of therapeutic radiographers/radiation therapists – Document analysis for a European educational curriculum. Radiography. 2022;28(4):955-963. doi:10.1016/j.radi.2022.06.017

B. Barbosa, C. Oliveira, I. Bravo, J.G. Couto, L. Antunes, S. McFadden, C. Hughes, P. McClure, J. Rodrigues, A.G. Dias. An investigation of Digital Skills of Therapeutic Radiographers/Radiation Therapists: A European survey of the current level of development and future educational needs. Submitted to Radiography journal.

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The consortium includes 7 organisations (universities, an oncology hospital, professional associations and a federation of associations) with the aim of improving education and training of TR/RTTs across Europe.

More information and results from other work-packages can be found on the SAFE EUROPE website: https://www.safeeurope.eu/outputs/

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IPO PORTO

List of Digital Skills of Therapeutic Radiographers/Radiation Therapists

Digital skills were identified and collated through a literature review combined with data and thematic analysis of the results of a European survey. From this analysis, 202 digital skills were identified, organised in 35 sub-themes and grouped into six main themes (see table 1). The resulting list was assessed by external experts with backgrounds and professional experience across all fields of radiotherapy (RT), such as Planning Image, Treatment Planning, Treatment Administration, Quality and Safety, Education and Research. To enhance the validity of this qualitative study and reduce research bias, a peer debriefing was also performed by presenting the results and obtaining feedback from RT professional practice experts (including two specialists and one manager), RT education and Medical Physics. Other skills, reported by survey respondents (TR/RTTs working in the European area), were also added to the final list.

The differences in regulation and education of TR/RTTs, and different access to technology across European countries, lead to gaps in digital skills. If there is a lack of digital skills to operate the existing and future technology, or TR/RTTs do not attempt to keep up with technological trends, this may reduce the safety and quality of patient care offered. Hence, it is recommended that the educational curricula of TR/RTTs should be strengthened to provide them with training in digital skills appropriate to their current and future needs. The list of digital skills presented is intended as an educational guideline for this digital training of TR/RTTs. To ensure safe and effective professional practice and to cope with the rapid digital evolution and transformation, continuous professional development (CPD) programmes should be considered in addition to educational programmes, focusing on the new needs that will arise.

Table 1 - List of TR/RTT's digital skills, represented in dimensions (themes).

Dimensions (themes)	Skill
Transversal Digital Skills	
Technologies/ Information Systems (IS)	- Open and close the Operating System - Log in and log out of applications - Set up the IS - Save data (e.g. CD, DVD, Pen Drive) - Import and export data (e.g. DICOM images, DICOM RT objects, RT data) - Print plans/images/data - Create PDF documents
Communication	- Create an internal communication channel (e.g. chat, intranet) between TR/RTT and other professionals - Create an external communication channel (e.g. mobile applications) between TR/RTT and service users (patient/carers) - Use professional e-mail - Create and disable a patient alert/note - Create multimedia content for patient education
Electronic Patient Record (EPR)	- Create a new patient record - Import patient data from other IS - Edit patient's demographic details - Acquire identification photo - Access RT patient data - Assign patient to a clinical trial - Add clinical data (e.g. treatment side effects, occurrences)
Patient Agenda	- Create a new appointment (e.g. Computerised Tomography scan, RT treatment) - Create and edit patient agenda - Use of a checklist for activities - Edit patient status (e.g. check-in, waiting time, treatment status) - Use data filters
Workstation	- Create "to do" worklist - Create staff agenda - Create charts flow and data graphics regarding all activities and tasks - Create and print out reports - Create template-based multiple appointments or tasks
RT Planning Image	
Computerised Tomography (CT)	- Create scan protocols - Set reference position (scan reference point) - Set the acquisition parameters (e.g. slice thickness, Field of View, kV, mA) - Acquire scout - Acquire and view CT scan - Set reconstruction parameters (e.g. algorithm, matrix size, coordinates) - Add patient setup notes (e.g. text, photo of patient positioning) - Create a clinical protocol for patient setup record
4D Computerised Tomography	- Add patient data into the respiratory motion control system - Create audio/video file for respiratory coaching - Define threshold values and acquire the respiratory cycle - Set acquisition parameters (e.g. amplitude, phase or

	breath-holding) - Synchronise respiratory cycle phase with CT image set
Image Processing and Enhancement	- Use visualisation tools (e.g. zoom, window level, scale, contrast and brightness) - Use editing tools (e.g. orientation, filters, reticle, graticule) - Use navigation tools (find and open patients' images)
Image Registration and Correlation	- Create a new registration - Select anatomical area/protocol - Select the set of images to be registered - Select registration method (automatic, interactive and manual) - Edit transformation results - Review and approve results
Image Segmentation and Contouring	- Add structures contours (automatic, semi-automatic or manual) - Edit contours' properties (e.g. name, color, margins) - Use contouring tools (e.g. geometric shapes, tracing, rubber) - Select and group structures - Use processing tools (e.g. interpolation, threshold, translation, rotation) - Use support tools (e.g. atlas, case library) - Review and approve segmentation
RT Treatment Planning	
Plan Treatment	- Create a new course and/or plan - Set treatment parameters (e.g. LINAC ID, beam, energy, patient orientation) - Set isocenter and/or markers - Add dose and fractionation data
Plan Parameters (forward planning)	- Create and edit fields (e.g. dimensions, gantry and collimator angles, segments) - Create reference images (Digitally reconstructed radiographs-DRRs) - Set accessories (e.g. MLC, blocks, compensators, wedges, bolus, cones) - Set field weighting - Create setup fields
Inverse Planning (IMRT/VMAT)	- Add fields (static or dynamic) - Select calculation models - Create support structures (e.g. "shell") - Set dose constraints and priorities (cost function) - Use geometric optimisation tools (e.g. angulation, sequence, direction) - Use dose optimisation tools (e.g. objective functions, fluencies) - Use templates (e.g. DVH estimation models) - Add checkpoints
4D Planning	- Set respiratory gating parameters (e.g. amplitude, phase or deep inspiration) - Set reconstruction for planning - Create setup fields - Add cine images to setup fields
SRS/SBRT Planning	- Set localisation device - Set treatment technique (e.g. stereotactic cones, IMRT, VMAT) - Set structure optimisation parameters - Set calculation properties

Dose Calculation	- Select the calculation parameters (e.g. grid size, calculation models) - Calculate dose distribution - Perform plan normalisation - Select the subtraction/accumulation imaging dose (Monitor Unit-MU)
Plan Evaluation	- Use visualisation tools (e.g. 2D/3D views, beam's eye view, room's eye view) - Use evaluation tools (cumulative or differential DVH, 3D dose distribution, isodoses, reference points) - Use review tools (e.g. plan sum/subtract, dose comparison) - Compare treatment plans - Use biological optimisation tools
Prerequisites for Treatment	- Calculate isocenter coordinates - Approve a plan for treatment - Create a plan revision - Sum treatment plans (e.g. Brachytherapy plans with external RT plans) - Change treatment machine - Replan (e.g. based on CBCT images) - Export a plan
RT Treatment Administration	
System Setup	- Start up and warm up linear accelerator (LINAC) and imaging devices - Shut down systems (e.g. LINAC, MLC) - Set to standby mode - Access the daily patient queue
Treatment Delivery Preparation	- Import and edit patient positioning data parameters (e.g. photos and setup notes) - Access the treatment plan (e.g. prescription, plan status, accessories and reference images) - Schedule treatment sessions - Schedule verification images - Set imaging parameters (e.g. imager position, collimation, filters) - Re-order and activate fields - Remove plans in cache
Treatment Verification: Conventional Techniques	- Acquire planar MV images (2D and 2D/2D) - Acquire planar kV images (2D and 2D/2D) - Optimise image quality (e.g. kV, mA, ms, MU) - Acquire CBCT images (3D/4D) - Set CBCT parameters (e.g. mode, filters and slice thickness) - Acquire scout and adjust scan range - Set reconstruction parameters (e.g. volume, slice interval and artefact removal) - Detect markers (automatic or manual)
Treatment Verification: Advanced Techniques	- Acquire images in integrated mode (e.g. during an IMRT treatment) - Acquire MV and kV images for respiratory gating treatments - Acquire ad-hoc images in a 4D treatment - Use fluoroscopy system - Use surface verification system - Use ultrasound (US) verification system - Use tracking verification system
Image Matching	- Use pre-analysis tools (e.g. scale and field alignment)

	- Use matching tools (automatic, manual or 3D reference markers) - Use matching view tools (e.g. split window, spyglass, reverse) - View kV or MV images in cine mode - Match 2D images (kV or MV) with reference image (DRR) - Match 3D images (CBCT) with reference image (planning CT) - Match 3D surface images with a reference surface - Match 3D US images with a reference position - Match real time tracking images with reference images
Image Analysis	- View online/offline images - Use analysis tools (e.g. grid, measurement parameters, graphics) - Add notes to images - Select and compare current and previous images - Change the shift between the scan reference point and the isocenter, based setup errors observed in previous images (e.g. NAL correction protocol) - Edit image status (e.g. approved, revised)
Treatment Delivery	- Apply couch shifts - Acquire treatment parameters (e.g. couch position and imaging device position) - Deliver treatment using manual or automatic mode - Set field sequence mode - Save the treatment session (e.g. automatic, manual or partial)
Respiratory Gating Treatment Delivery	- Setup respiratory gating system on the patient/treatment room - Select the respiratory cycle reference session - Adjust threshold, scale and audio/visual instructions - Use analysis tools for pre-treatment verification - Perform and record the treatment with respiratory control - Check the history of the respiratory gating treatment
SRS/SBRT Treatment Delivery	- Perform verification procedures (e.g. isocenter, X-ray system) - Set X-ray system parameters - Set patient positioning parameters (e.g. tolerances, detection accessories) - Perform patient positioning using robotics - Acquire verification images - Use tools for anatomical match analysis - Perform geometric corrections
Quality, Safety and Risk Management	
Quality Assurance	- Perform daily checks (e.g. isocenter, dose output) - Evaluate equipment performance - Record occurrences related to the equipment and accessories - Create quality assurance programmes - Create protocols/templates (e.g. treatment site, treatment technique, image verification)
Security	- Record all procedures concerning the radiation delivered - Review acquired, edited and replaced parameters - Review LINAC, MLC and imaging system failures/interlocks

	- Review import/export history - Use barcode reading system (e.g. patient, accessories, cones) - Check occupational exposure dose
Risk Management	- Use collision detection systems - Report accidents and incidents on a platform (e.g. SAFRON, ROSEIS) - Develop risk management programs - Audit the workflow and treatment courses (e.g. plan changes, schedules) - Create evaluation and prevention reports
Data Protection	- Create new user and/or group - Edit user and/or group permissions - View patient data access records - View operating system and application access logs
Information Integrity	- Detect data recording failures - Recover data from backup files - Confirm MU delivered in case of emergency/loss of power - Use backup tools (e.g. complete/ incremental/ scheduled) - Review the consistency of checks, file wipes and backups
Management, Education and Research	
Department IS Administration and Management	- Use data collection tools of the activities performed (export data, productivity) - Code activities (e.g. procedures, diagnostics) - Use billing tools (billing codes) - Create automatic reports (e.g. daily activities, billing) - Perform market research (e. g. supplies, technology) - Use tools to automate work schedules (weekly/monthly) - Create organisational systematisation tools - Manage Treatment Planning System database - Manage IS - Manage hardware - Access all the functions of IS - Manage directories
Education	- Create multimedia content for new professionals/trainees education - Create training programs (for students and professionals) - Create dissemination platforms (e.g. webinars, newsletter) - Perform awareness-raising actions related to radiotherapy (e.g. videos, presentations, social networks)
Research	- Use search engines and digital libraries (e.g. white and grey literature) - Collect and evaluate data for research - Use data analysis software (e.g. spreadsheet, statistical software)

DICOM: Digital Imaging and Communications in Medicine; LINAC: Linear Accelerator; MLC: Multileaf Collimator; IMRT: Intensity-modulated Radiation Therapy; VMAT: Volumetric Modulated Arc Therapy; DVH: Dose-volume Histogram; CBCT: Cone-beam Computed Tomography; NAL: No action level; SAFRON: Safety in Radiation Oncology; ROSEIS: Radiation Oncology Safety Education and Information System.