DIGI4ME

REPORT ON DIGITAL SKILLS NEEDS AND GAPS IN HEALTH SECTOR

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HEALTH SECTOR SKILL ALLIANCE FOR CREATING INNOVATIVE AND EFFICIENT VET PROGRAMMES AND IMPROVING THE DIGITAL SKILLS OF MEDICAL PHYSICS AND HEALTH PROFESSIONALS

WP2 - SPECIFICATION AND ANALYSIS OF CURRENT POLICIES AND DIGITAL SKILLS NEEDS IN HEATH.

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DIGI4ME PROJECT

"Health sector skill alliance for creating innovative and efficient VET programmes and improving the digital Skills of medical physics and health professionals"

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BACKGROUND

Digi4ME

Digi4ME will enhance digital skills training in the health care sector as well as educational institutes, VET centres, health care associations and research institutes. The project will promote exchange of skills, experience and accessibility which will be embodied in a single high quality training framework to improve Digital Skill training all over Europe. The increasing demand for healthcare services, driven by the demographic shifts throughout Europe (Maresso et al., 2015), will increase the number of jobs and the required skills of professionals in the health sector. The increasing demand to recruit healthcare workers (Liu et al., 2017) can be explained by several factors such as the increase of world population and ageing populations that need long term healthcare services (Schulz et al., 2014, Bayar et al., 2021). The health sector is expected to have a 23% increase in employment by 2025 while over time new medical technologies are evolving and the skills that health professionals possess are a key determinant in the delivery of high-quality services to wider society. The quality and competency of digital skills of healthcare professionals are acknowledged to be of extreme importance at EU level.

The project will identify and define the educational content by determining the digital skills that every health professional must possess to use eHealth solutions effectively. This process will involve verification of the specific educational needs of doctors, operators and other professionals of digital technology of medical imaging equipment. Then partners of the project will develop user-adapted training modules on the specific context concerning digital image processing and administration, including recent changes to the pedagogical landscape of healthcare distance learning with the use of an innovative Vocational Open Online Courses (VOOCs) for Digital Skills. This will be performed after an evaluation of the functionality of the educational tools through the pilot study over 4 EU countries. After testing the VOOCs, the educational framework will be accredited using the appropriate EU directives and national agencies.

Work Package 2 (WP2)

WP2 will identify training needs and digital skills for health sector and industry across Europe. WP2 will analyse the necessities for digitals skills and the needed knowledge, competitiveness and innovation both at a European level as well as within partner countries. The material will provide examples of good practices of digitals skills and will help to identify possible development pathways of the training participants. In order to determine digital skills for healthcare, a review of the relevant literature will be conducted with the following objectives:

- Determine skills needed in the health sector from the partner countries
- Identify the educational needs of VET students in the health sector and match them with the qualifications of job seekers
- Offer training to the job seekers in their VET-institution in order to prepare them for the needs of their new job or to help them to get more job offers
- Identify specific modules that could be integrated in VET curricula

This desk based research, along with survey and interview data will feed into two reports on:

1. Identification of skills and competency needed in Digital Skills for Health Professional

2. Guidelines of digital Skills for VET Students in health

Report Overview

Scope of Report

The report will present the results of the research in the four partner countries as well the wider EU setting. It will highlight differences and digital skills needs in Partners Countries and EU level. The literature review, web questionnaires and the face-to-face interviews will be presented in the report and will support the main findings of the studies. The result aims to summarize findings from the publications, existing approaches, project initiatives, studies, surveys, interviews etc. in the open online education's overall approaches and specifically at higher education conditions in the Partners Countries and EU.

The aim of this task is to identify and analyse the existing research evidence on digital skills, digital competences and qualifications of health professional. The need analysis in digital skills will be conducted on EU level (mainly by the INHWE) and in the countries of the project partners. Initially, the main aim of the analysis is to identify the digital skills requirements in health sector and the educational characteristics of the VET programs on EU level. Then, when the gap between them is specified and analysed, the aim of the project is to bridge it. Partners will then be able to collect and specify current innovation needs on health domain mainly by web surveys and by interviewing the members of networks in the sector. Indeed, face-to-face interviews with employers and professionals in health sectors will be conducted as they offer advantages in terms of data quality in the context of a project of this nature.

Digital Skills

Digital solutions have the potential to radically transform health systems and education by providing better outcomes, service and quality through technopolitical advances. Europe faces increased demand for health services due to ageing populations, rising patient mobility, and a diminishing supply of health workers caused by retirement rates that surpass recruitment rates. Digital technologies, including eHealth advancements, aim to tackle these issues by creating smarter healthcare process, allowing services to be delivered closer to patients, and reducing the workload of healthcare professionals. However, health professionals' digital skills often fall short of the required level to use such new technology. The skills gap of health sector and especially that of digital skills is a European problem that affects the efficiency of European health services and has a paramount impact on society. Handling this issue effectively at European level, ensuring the transferability, transparency and applicability of the proposed solutions, requires the transnational cooperation between all relevant stakeholders: higher education institutes, VET providers, associations and networks in health workforce education, accreditation organizations.

METHODOLOGY

Literature Review

A scoping review method will be used to explore literature sources in relation to the aim outlined above. This method has become an increasingly popular approach for identifying and collating research evidence in a specific field of interest (Pham et al, 2014; Sucharew and Macaluso, 2019). It is suited to examining both the breadth and depth of literature available in terms of volume, nature and characteristics in order to present a narrative or descriptive overview. It has become an increasingly common approach for mapping broad topics (Arksey and O'Malley, 2005). The scoping review differs from a systematic review in that it incorporates all study methods and designs, all types of literature sources including published, 'unpublished' and 'grey' literature. It does not seek to evaluate the quality of studies or research findings, but it does follow the principles of systematic reviews in that reviews should be robust, and documented with sufficient detail to be replicable, reliable, and valid, particularly as there is potential for bias due to selective inclusion criteria (Arksey and O'Malley, 2005; Grant, 2009; Munn et al, 2018). Thus, this method is best suited for the overall objective of this task.

In order for the Literature Scoping Review search to be successful it is important to explore both academic peer reviewed articles along with grey literature. Grey literature can be found in many forms such as: government and non-governmental reports, conference presentations and projects, industry standards, documentation (from private or public sector) and other official documentation (Alberani et al, 1990). In order to search for all available literature effectively, Booth's (2013) triple plus strategy will be implemented. This strategy provides a systematic method for searching literature. Firstly, Google Scholar will be used for academic sources. Secondly, specialist grey literature database (OpenGrey) will be searched and then thirdly, supplementary strategies are examined which will include a standard google search and the websites of large international organisation (WHO, OECD, European Commission etc).

All data will be collated in a table such as the one below:

Search Area	Search Term	Found	Applicable	Notes
Database				
Open Grey	Digital skills	142	3	*Add notes here about relevance, further reading, key articles etc..*
	Digital skills health			
	Digital skills health workforce			
	Etc…			

Survey

A Delphi study methodology was used to determine the extent to which stakeholders agreed about a given digital skill or issue. A Delphi study is usually conducted through questionnaires to collect data

to develop consensus over ideas, concepts or processes. Consensus research methods are often useful in the development of policies and recommendations which this report aims to make. The Delphi technique has features that are beneficial to this type of research:

- Participants are a discrete group of individuals with expertise or experience of the topics seeking consensus;
- Consulting with the participants follows a structured format that allows research to be democratic, transparent and time-limited;
- Conclusions carry more weight than those from a less formal decision-making process such as a focus group or a survey questionnaire.

The first round of data collection involved a synthesis of statements and questions which formed the basis for the questionnaire. An initial scoping review of the literature was conducted prior to the projects' start date and a further examination of literature was ongoing when the questionnaire was being developed. Participants were recruited from stakeholders in relevant healthcare or educational settings for a multi-professional outlook. An introductory email was sent to selected participants, as well targeted social media posts with embedded links to the digi4me website. Initial contacts were asked to forward the email to other key individuals in their organization or networks. Individuals expressing interest were able to access the questionnaire and complete it anonymously.

Interviews

The interviews form is a crucial part of WP2 to ensure extra depth to task T2.1 where the project will identify and analyse the existing research evidence on digital skills, digital competences and qualifications of health professionals. Interviewees will be asked a number of questions to support partners in collecting and specifying current innovation needs in the health domain. Online and face-to-face interviews with employers and professionals in health sectors will be conducted as they offer advantages in terms of data quality in the context of a project of this nature. Semi-structured interviews will be held with educators and practitioners from various healthcare domains, sectors and professions. These interviews will focus on the stakeholders accounts of their personal and practical experiences of using and teaching digital skills to in practice and to healthcare students. These particular stakeholders will be selected for interview as they are the most likely to hold the greatest insights into the digital skills of the health workforce.

Semi structured interviews have been chosen because they "are conducted on the basis of a loose structure consisting of open-ended questions that define the area to be explored, at least initially, and from which the interviewer or interviewee may diverge in order to pursue an idea in more detail". (Britten, 1995 p. 251). Miles & Gilbert (2005) also point out that using semi structured interviews offer a great way of finding out 'why' rather than 'how many' or 'how much'. Thus, including semi-structured interviews in the research design of Digi4ME will provide an additional layer of understanding (Gubrium & Holstein, 2002). Not only will the project reveal what kind of digital skills are missing, but it will also investigate some in-depth cases addressing the questions how and why these gaps in knowledge exist.

FINDINGS

Literature Review

The literature review resulted in 29 sources of information which will answer the question of what requirements and gaps in knowledge related to digital skills exist within healthcare and amongst healthcare professionals. The table below (table 1) provides information relative to the methodology used to detect the relevant literature, as well as the process by which it was mapped through the search. The data on table 1 indicate that the database search and supplementary Google search for academic literature produced similar levels of results. The search for grey literature produced similar results, with the database search resulting in 1 source and the website analysis contributing a further 4 sources.

Table 1: Overview of scoping review.

Search Area	**Search Term**	**Applicable**	**Notes**
Academic Database			
Google Scholar	Digital skills	9	*Due to the high number of results the search was narrowed down to articles from 2011 to present day*
	Digital skills health		
	Digital skills health workforce		
Grey Literature Database			
Open Grey	Digital skills	1	*Multiple publications excluded due to research nature (PhD etc)*
	Digital skills health		
	Digital skills health workforce		
Standard Web Search			
Google	Digital skills	15	*Due to high number of results first 10 pages reviewed*
	Digital skills health		
	Digital skills health workforce		
Websites			
WHO	Search terms as above	1	*None*
OECD		0	
EC		3	

The overall search outcome provided a wide range of varied articles and documents from both the private and public sector, as well as from the EU and further afield. These articles identified and

produced findings on both key topic areas, namely 'Gaps in Knowledge' and 'Sills / Competencies' which is the key aim of this report. The findings from each topic are outlined below:

Gaps in Knowledge

When evaluating the articles for their assessment on gaps in knowledge of healthcare professionals' digital skills, it became clear that two primary issues maintained prevalence. Firstly, the complexity of digital skills required within healthcare meant that gaps arose in many different areas of clinical and non-clinical practice. Secondly, the sheer number of different digital technologies used in healthcare (e.g. prescribing or surgery) meant that different professional groups (and intra-professional groups) created a complexity in assessing knowledge and skill gaps.

Although there is a clear 'call to arms' to promote and facilitate digital health competencies in the education and training curricula of all health professionals and allied workers (WHO, 2021), this has created a wide spectrum of differing curricula which creates varied gaps in health provider knowledge. Therefore, health professionals have credible competencies in the use of information and in problem solving, often due to non-digital clinical training, but they do not know the instrumental means of the new digital ecosystem of access, production, management and dissemination of information (Fernández-Luque et al., 2017). Health professionals would appear to confirm this assessment given from their responses in research conducted by Machleid et al. (2020) shown below:

Figure 1: Responses to the statement: "Please define eHealth in your own words." The percentages are in relation to the number of definitions given (Machleid et al., 2020).

The graphic above shows that while it is generally accepted that there is a lack of digital skills, concerns have also been raised about what the appropriate level of expectations for health professional are, when it comes to using digital technology. For instance, Loizou et al. (2021) note that health professionals largely do not possess advanced data management and analytical skills. However, questions were raised whether they should be expected to possess such skills or to what level they should be competent and where non-clinical personnel should support them within the healthcare ecosystem. The publication entitled 'Digital transformation Shaping the future of European Healthcare' by Deloitte in 2020 shows the variation of differing types of clinical technologies being used by clinicians across Europe:

	Europe	Denmark	Germany	Italy	Netherlands	Norway	Portugal	UK
Electronic health record	81%	95%	77%	69%	97%	89%	74%	87%
Prescribing	62%	73%	13%	67%	97%	86%	96%	69%
Online appointment booking	54%	61%	38%	53%	67%	41%	66%	62%
Apps for Clinicians	51%	54%	44%	53%	70%	40%	55%	52%
Online access platforms/tools (for primary or hospital care)	46%	50%	23%	47%	49%	51%	68%	57%
Telemedicine	43%	61%	30%	38%	59%	40%	45%	47%
Rostering	37%	29%	52%	14%	46%	39%	23%	49%
Automation of pharmacies/ drug dispensing	30%	38%	23%	25%	62%	34%	13%	35%
Point of care diagnostics	26%	24%	31%	10%	43%	35%	9%	37%
Patients Apps/Wearables	22%	26%	21%	18%	35%	15%	17%	26%
Remote vital sign monitoring	22%	24%	22%	21%	24%	20%	13%	25%
Automation of other clinical tasks	19%	26%	25%	9%	28%	15%	12%	22%
Voice recognition tools	16%	16%	26%	8%	10%	26%	1%	20%
Robotics	8%	8%	13%	8%	5%	6%	3%	8%
Genomics data (storing or using)	8%	14%	11%	6%	1%	5%	3%	10%
Radio Frequency Identification tags (RFID)	6%	3%	8%	3%	3%	2%	5%	9%
Artificial Intelligence technologies	5%	7%	7%	5%	5%	6%	2%	5%
Virtual reality	5%	4%	4%	5%	5%	5%	0%	7%

Percentage of survey respondents

Figure 2: Variations in the percentage of clinicians using different types of digital technologies (Deloitte, 2020).

It is clear that "*medical education and CPD should reflect the changing roles of doctors [along with other health practitioners] and the new skills they require. These skills include data analytics in healthcare, genomics and bioinformatics, AI [Artificial Intelligence] in health, telemedicine, smart health devices and mHealth, training with digital health technologies, such as virtual reality (VR) and augmented reality (AR), ethical considerations, communication skills with patients, relatives and healthcare team, and legal implications of digital health tools"* (CPME, 2020). The relevance of addressing skill gaps and also the overall objective of this project is supported by Digital Health Europe (2021) who state that it is imperative to implement a plan of investment on the education of professionals, that includes multidisciplinary collaboration and lifelong training for innovation and digital skills.

Competencies and Skills

Narrowing down specific skills and competencies that healthcare professionals should possess, and thus to be taught, was just as challenging as identifying gaps in knowledge. Some researchers believe that healthcare practitioners require over 50 health informatics competencies to effectively practice (Jidkov et al, 2019). This is hard to map and even harder to find a brad conscious for creating innovative and efficient VET programmes and improving the digital Skills of medical physics and health professionals. Therefore, the findings from 6 key frameworks have been mapped below which show broader competency groupings which help narrow down core areas of training and understanding.

Table 2: Mapping of 6 key frameworks on digital skills and competencies for health professionals.

Skills/Competence	**DigComp 2.1 (2021)**	**Jisc (2015)**	**HITComp (2018)**	**Fernández-Luque (2021)**	**eHLA (Karnoe, 2018)**	**CPME (2020)**
Information/Data	x	x	x	x	x	x
Communication	x	x	x	x		
Content Creation, Research	x	x		x		
Safety/Security	x	x		x		
Problem Solving	x			x		x
Technical Proficiency		x	x		x	x
Teaching, Learning, Self-Development		x			x	
Patient Interactions			x			x
Clinical Technology			x			x
Administration and Legal / Ethical			x		x	x

Many of the broad competency themes outlined in the publications above contain a number of subthemes which provide greater insight into the digital skills required for healthcare practitioners. For example, the Standing Committee for European Doctors (2020) believe that general digital skills include sub-skills of data protection, problem-solving with ICT tools and software. Technical digital skills would contain telemedicine, Health apps and smart devices. While patient-doctor relationship skills (as outlined in table 2) are inclusive of digital communication and digital collaboration. This is supported by Fernández-Luque (2021) who outline five broad competencies as below:

1. *Information literacy* - Identify, locate, retrieve, store, organize, and analyze digital information, assessing its purpose and relevance.
2. *Communication* - Communicating and collaborating in digital environments, sharing resources through online tools, connecting and collaborating with others through digital tools, and interacting and participating in communities and networks; intercultural awareness.
3. *Content creation* - Creating and editing new content (texts, images, videos...), integrating and reworking previous knowledge and content, making artistic productions, multimedia content, computer programming, knowing how to apply intellectual property rights and licenses for use.
4. *Security* - Personal protection, data protection, digital identity protection, security use, protecting health, safe and sustainable use.
5. *Problem solving* - Solving technical problems, identifying needs and technological responses, innovating and creatively using technology, identifying digital competence gaps.

The European Health Parliament (2016) also made some useful recommendations which support skill and competency development:

- Health professionals should possess skills and aptitude for communication, data analysis, computer literacy, medical devices compatibility, data protecting programs, mobile apps, cloud storage, using the internet, and have the ability to read, understand and forward information using a smart device.
- Health informatics professionals should acquire skills in information security, interoperability, analysing data, design and implementation of tools to measure data, software development, 3D image processing, project management and communication.
- Non-clinical and administrative staff should possess skills in project management, communications, computer literacy, information security, and the use of clinical software
- IT professionals working in the healthcare environment should possess skills in data privacy, information security, ethics, software engineering and database development.

Survey

The questionnaire consisted of 6 sections of questions and was answered by 300 health professionals from all over Europe.
Various specialties of health professionals took part in the survey, such as Biologists, Dieticians, Managers, Medical Doctors, Medical Engineers, Medial Physicists, Medical Technologists, Midwifes, Nuclear Medicine Imaging Technologists, Nurses, Nurse Educators, Nutritionists, Occupational Therapists, Pharmacy Technicians, Physiotherapists, Radiation Technologists, Radiographers, Radiology Doctors, Radiotherapist and Radiotherapy Technologists.

For the analysis of the questionnaire, the participants were divided into 3 categories of health professionals as follows:

Health Professionals Group		
Supporting Professionals (SP)	**Related Professionals (RP)**	**Mostly Related Professionals (MRP)**
Biologists, Dieticians, Managers, Nutritionists,	Midwifes, Nurses, Nurse Educators	Medical Doctors, Medical Engineers, Medial Physicists, Medical Technologists, Nuclear

Occupational Therapists, Pharmacy Technicians,		Medicine Imaging Technologists, Radiation Technologists, Radiographers, Radiology Doctors, Radiotherapist and Radiotherapy Technologists.

1 Hardware Interaction

This section consisted of three questions. The first question examined how effectively health professionals can interact with digital technologies, the second how effectively they can use a variety of devices to input and process medical data and the last question whether the interviewees used the appropriate monitor for each modality. To study the results, the responds have been concentrated on mostly related professionals, supporting professionals and related professionals.

Table 1.1 Interact effectively with a variety of digital technologies such as computers, laptops, tablets, and smartphones.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Interact effectively with a variety of digital technologies such as computers, laptops, tablets, and smartphones.	At basic level with guidance	Count	4	2	17	23
		%	4.7%	4.9%	11.0%	8.2%
	At basic level without guidance	Count	19	3	44	66
		%	22.4%	7.3%	28.4%	23.5%
	Competent to perform straightforward tasks	Count	22	16	51	89
		%	25.9%	39.0%	32.9%	31.7%
	At advance level to perform non routine tasks	Count	25	11	25	61
		%	29.4%	26.8%	16.1%	21.7%
	At expert level to perform complex tasks and guide others	Count	15	9	18	42
		%	17.6%	22.0%	11.6%	14.9%
Total		Count	85	41	155	281
		%	100.0%	100.0%	100.0%	100.0%

Results showed that healthcare providers are confident to interact with a variety of digital technologies as well as, with a variety of input devices. Regarding the first 2 two questions, the total

sample of respondents is divided approximately equally between the basic, the average and the advanced level. The vast majority of the sample (> 90%) seem to be able to perform actions without guidance.

Table 1.2 Use effectively a variety of devices to input and process data such as keyboard, mouse, touchpad, workstation console, touchscreen, voice commands - voice recognition and digital pens.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use effectively a variety of devices to input and process data such as keyboard, mouse, touchpad, workstation console, touchscreen, voice commands - voice recognition and digital pens.	At basic level with guidance	Count	9	4	21	34
		%	10.6%	9.8%	13.5%	12.1%
	At basic level without guidance	Count	17	3	38	58
		%	20.0%	7.3%	24.4%	20.6%
	Competent to perform straightforward tasks	Count	20	10	59	89
		%	23.5%	24.4%	37.8%	31.6%
	At advance level to perform non routine tasks	Count	26	14	21	61
		%	30.6%	34.1%	13.5%	21.6%
	At expert level to perform complex tasks and guide others	Count	13	10	17	40
		%	15.3%	24.4%	10.9%	14.2%
Total		Count	85	41	156	282
		%	100.0%	100.0%	100.0%	100.0%

As far as the last question is concerned, about one in three participants is either able to carry out these activities under guidance or has no knowledge at all. The percentage of most related professionals who state that they have no knowledge on the subject is about 5 times lower than the corresponding percentage of the rest of the professional groups.

Table 1.3 Use the appropriate monitor for each modality to ensure the correct display conditions of medical images. You ensure that the environmental conditions are met according to monitor specifications (ambient light conditions, monitor calibration).

			Specialty	Total

			Supporting Professionals	Related Professionals	Mostly Related Professionals	
Use the appropriate monitor for each modality to ensure the correct display conditions of medical images. You ensure that the environmental conditions are met according to monitor specifications (ambient light conditions, monitor calibration).	At basic level with guidance	Count	19	3	28	50
		%	22.6%	7.5%	18.1%	17.9%
	At basic level without guidance	Count	13	8	50	71
		%	15.5%	20.0%	32.3%	25.4%
	Competent to perform straightforward tasks	Count	20	11	39	70
		%	23.8%	27.5%	25.2%	25.1%
	At advance level to perform non routine tasks	Count	13	12	20	45
		%	15.5%	30.0%	12.9%	16.1%
	At expert level to perform complex tasks and guide others	Count	6	2	14	22
		%	7.1%	5.0%	9.0%	7.9%
	No knowledge	Count	13	4	4	21
		%	15.5%	10.0%	2.6%	7.5%
Total		Count	84	40	155	279
		%	100.0%	100.0%	100.0%	100.0%

2. DICOM Standard & Function

This five-question section examined the level of understanding of health professionals regarding various aspects of DICOM images, including the use DICOM functions, the structure of DICOM images and DICOM header information, the jargon of DICOM images, the image characteristics related to the size of the image file and the image characteristics related to different medical imaging modalities.

The results are as expected, as in the first question the percentage of participants from relevant professions who declare no knowledge is four times higher than that of participants from relevant professions, while the corresponding percentage from supporting professions is twice the percentage of participants from relevant professions.

Although DICOM functions are tools of everyday work, our results show that about 40% of the most relevant professionals either state that they have no knowledge of these tools at all or state that they work only at a basic level with guidance.

In addition to all the groups, 40 to 80% of the participants either do not have any relevant knowledge or are only able to work at a basic level with guidance. This data leads to the conclusion that there is significant room for improvement.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Understand and use where applicable, DICOM functions such as DICOM Store, DICOM Query and Retrieve, DICOM Sent, DICOM Print, DICOM Modality Worklist (MWL) and DICOM Modality Performed Procedure Step (MPPS).	At basic level with guidance	Count	19	13	54	86
		%	22.4%	31.7%	34.6%	30.5%
	At basic level without guidance	Count	6	6	37	49
		%	7.1%	14.6%	23.7%	17.4%
	Competent to perform straightforward tasks	Count	5	4	26	35
		%	5.9%	9.8%	16.7%	12.4%
	At advance level to perform non routine tasks	Count	3	5	19	27
		%	3.5%	12.2%	12.2%	9.6%
	At expert level to perform complex tasks and guide others	Count	2	1	8	11
		%	2.4%	2.4%	5.1%	3.9%
	No knowledge	Count	50	12	12	74
		%	58.8%	29.3%	7.7%	26.2%
Total		Count	85	41	156	282
		%	100.0%	100.0%	100.0%	100.0%

Although understanding the structure of DICOM images and managing the data in the image header is a routine task for the most relevant professionals in the field, more than 50% is only able to meet a basic level of with or without guidance.

In addition, the percentage of participants from the group of the most relevant health professionals who possess expert level skills is extremely low, of the order of 6%.

			Specialty

			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Understand the structure of DICOM images and extract information from DICOM header.	At basic level with guidance	Count	19	15	49	83
		%	22.4%	37.5%	31.8%	29.7%
	At basic level without guidance	Count	9	3	35	47
		%	10.6%	7.5%	22.7%	16.8%
	Competent to perform straightforward tasks	Count	5	5	21	31
		%	5.9%	12.5%	13.6%	11.1%
	At advance level to perform non routine tasks	Count	4	4	19	27
		%	4.7%	10.0%	12.3%	9.7%
	At expert level to perform complex tasks and guide others	Count	1	1	9	11
		%	1.2%	2.5%	5.8%	3.9%
	No knowledge	Count	47	12	21	80
		%	55.3%	30.0%	13.6%	28.7%
Total		Count	85	40	154	279
		%	100.0%	100.0%	100.0%	100.0%

Given that the third question concerns the basic terminology of the DICOM protocol, the percentage of 15% of the most relevant health professionals who state that they have no knowledge is a surprisingly high.

It is noteworthy that starting from the group of the most relevant professionals and ending up in the group of supporting professions, the percentages of participants without knowledge or with skills at a basic level, range from 65 to 80%, percentages that are considered quite high.

			Specialty

			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Understand jargon of DICOM images such as resolution, high-contrast resolution, low contrast resolution, bit depth, pixel size, ROI units etc.	At basic level with guidance	Count	16	14	45	75
		%	18.8%	34.1%	29.0%	26.7%
	At basic level without guidance	Count	11	6	38	55
		%	12.9%	14.6%	24.5%	19.6%
	Competent to perform straightforward tasks	Count	7	6	21	34
		%	8.2%	14.6%	13.5%	12.1%
	At advance level to perform non routine tasks	Count	7	3	17	27
		%	8.2%	7.3%	11.0%	9.6%
	At expert level to perform complex tasks and guide others	Count	0	1	12	13
		%	0.0%	2.4%	7.7%	4.6%
	No knowledge	Count	44	11	22	77
		%	51.8%	26.8%	14.2%	27.4%
Total		Count	85	41	155	281
		%	100.0%	100.0%	100.0%	100.0%

The subject of the fourth question is more specialized than the previous one. Yet, in the group of the most relevant professionals, the same picture is observed, i.e., large percentages (approx. 65%) of participants with no or limited abilities. The same picture is recorded for the other two groups of professionals.

Finally, in the group of supporting professions, twice the percentage of participants is recorded in relation to the other two groups of professionals, a fact that is considered expected

	Specialty

			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Understand how image characteristics affect the file size.	At basic level with guidance	Count	20	11	48	79
		%	23.5%	26.8%	31.2%	28.2%
	At basic level without guidance	Count	10	8	33	51
		%	11.8%	19.5%	21.4%	18.2%
	Competent to perform straightforward tasks	Count	10	8	22	40
		%	11.8%	19.5%	14.3%	14.3%
	At advance level to perform non routine tasks	Count	14	6	16	36
		%	16.5%	14.6%	10.4%	12.9%
	At expert level to perform complex tasks and guide others	Count	4	3	13	20
		%	4.7%	7.3%	8.4%	7.1%
	No knowledge	Count	27	5	22	54
		%	31.8%	12.2%	14.3%	19.3%
Total		Count	85	41	154	280
		%	100.0%	100.0%	100.0%	100.0%

The percentage of participants from the most relevant professions who perceive the differences between the image characteristics of different modalities is exceptionally low, of the order of 25% compared to what is expected for experts.

Amongst the participants in the other professional groups, 75 to 85% range from no knowledge to basic level. Further, one in five participants in the related professions group and one in two participants in the support professions group appear to have no knowledge of the subject of this question.

	Specialty

			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Understand differences on image characteristics among modalities such as DX, CT, MR, XA, CR, RF, NM, PT and other.	At basic level with guidance	Count	21	16	26	63
		%	25.0%	39.0%	16.9%	22.6%
	At basic level without guidance	Count	8	5	52	65
		%	9.5%	12.2%	33.8%	23.3%
	Competent to perform straightforward tasks	Count	8	4	31	43
		%	9.5%	9.8%	20.1%	15.4%
	At advance level to perform non routine tasks	Count	7	7	21	35
		%	8.3%	17.1%	13.6%	12.5%
	At expert level to perform complex tasks and guide others	Count	0	0	15	15
		%	0.0%	0.0%	9.7%	5.4%
	No knowledge	Count	40	9	9	58
		%	47.6%	22.0%	5.8%	20.8%
Total		Count	84	41	154	279
		%	100.0%	100.0%	100.0%	100.0%

Overall, the results of this study showed that a significant portion of healthcare professionals (about 50%) have no knowledge or consider themselves at basic level for DICOM Standard & Functions. On the expert level, only a mere 5% considers themselves as an expert on the subject. It is worth noting that there is statistically significant difference in almost all questions about DICOM Standard & Functions and the Specialty. The Mostly Related Professionals have better understanding of DICOM Standard & Functions comparing them to Supporting Professionals and Related Professionals but they also have significant portion of their professionals that need improvement on the subject. DICOM is a worldwide standard that is used in approximately all the imaging modalities. Increasing the skills of healthcare providers with training on this subject is expected to help them to manage more effectively the patient data and services in healthcare can be therefore improved in several ways. Understanding how DICOM image files and functions work can achieve a better access and processing of the patient

images, help on transferring images to other workstation consoles (i.e. different hospitals), optimize storage and increase the viewing performance allowing them to perform diagnosis more effectively.

3 Medical Imaging Processing Tools

The third part of the questionnaire consisted of 4 questions and dealt with whether users felt comfortable with Medical Imaging Tools.

The first question examined the competence of health professionals in using qualitative and quantitative analysis tools, whereas the second question examined how they felt by using the contrast and brightness adjustments, ROI measurements, spatial calibration, and the use of filters. The knowledge and competence of users in advanced processing methods such as 3D reconstruction and virtual processing tools, were examined in question 3, whereas the last question examined user's skills regarding advanced computer aided tools such as automatic analysis tools, CAD and AI tools.

As can be seen in Table 3.1 below, Question 1's results were quite logical with some exemptions. The most important outcomes are believed to be, that a percentage of 8.4% of the Mostly Related Professionals (MRP), have no knowledge on using qualitative and quantitative analysis as compared with 26.8% and 39.0% of the Related Professionals (RP) group and the Supporting Profession (SP) group. Obviously, using qualitative and quantitative analysis tools is of utmost importance, so all professionals in the MRP group should have at least some knowledge. Furthermore, although only 12.2% of the RP group replied that they have competence using these tools at basic knowledge without guidance, 17.1% replied that they may use these tools to perform straightforward tasks. Something similar appears in the SP group, which is obviously quite peculiar.

Table 3.1 Use of qualitative and quantitative analysis

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use for qualitative and quantitative analysis.	At basic level with guidance	Count	21	9	45	75
		%	25.6%	22.0%	29.2%	27.1%
	At basic level without guidance	Count	7	5	45	57
		%	8.5%	12.2%	29.2%	20.6%
	Competent to perform straightforward tasks	Count	15	7	23	45
		%	18.3%	17.1%	14.9%	16.2%
	At advance level to perform non routine tasks	Count	6	7	17	30
		%	7.3%	17.1%	11.0%	10.8%
		Count	1	2	11	14

	At expert level to perform complex tasks and guide others	%	1.2%	4.9%	7.1%	5.1%
	No knowledge	Count	32	11	13	56
		%	39.0%	26.8%	8.4%	20.2%
Total		Count	82	41	154	277
		%	100.0%	100.0%	100.0%	100.0%

The next question whose results are presented in Table 3.2, examined the competence of users in using various adjustment tools. Once again, results indicated that a high percentage of the MRP, 21.4% have no knowledge in using these tools, which is something that needs to be examined in detail and rectify.

The same odd results as before, may be seen in this table as well. It is odd to discover that although a relatively small percentage 12.2% and 9.6% of the RP and the SP groups respectively have only basic knowledge enabling them to use the tools without guidance, a higher percentage up to, 22.0% and 14.5% of those groups are able to perform straightforward tasks!

Table 3.2 Use of contrast and brightness, ROI measurements, spatial calibration m use of filters.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use for contrast and brightness adjustment, ROI measurements, spatial calibration, use of filters (i.e. Sharpen, Blur).	At basic level with guidance	Count	18	10	39	67
		%	21.7%	24.4%	25.3%	24.1%
	At basic level without guidance	Count	8	5	35	48
		%	9.6%	12.2%	22.7%	17.3%
	Competent to perform straightforward tasks	Count	12	9	19	40
		%	14.5%	22.0%	12.3%	14.4%
	At advance level to perform non routine tasks	Count	7	3	13	23
		%	8.4%	7.3%	8.4%	8.3%
	At expert level to perform complex tasks and guide others	Count	0	3	15	18
		%	0.0%	7.3%	9.7%	6.5%
	No knowledge	Count	38	11	33	82

	%	45.8%	26.8%	21.4%	29.5%
Total	Count	83	41	154	278
	%	100.0%	100.0%	100.0%	100.0%

The results of the competence of users in applying advanced processing methods, are presented in Table 3.3.

Table 3.3 Use of understanding advance processing methods.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use for understanding, if applicable, advanced processing methods such as 3D reconstructions and virtual processing tools.	At basic level with guidance	Count	21	14	45	80
		%	24.7%	35.0%	29.4%	28.8%
	At basic level without guidance	Count	6	5	25	36
		%	7.1%	12.5%	16.3%	12.9%
	Competent to perform straightforward tasks	Count	6	7	20	33
		%	7.1%	17.5%	13.1%	11.9%
	At advance level to perform non routine tasks	Count	4	3	17	24
		%	4.7%	7.5%	11.1%	8.6%
	At expert level to perform complex tasks and guide others	Count	1	0	6	7
		%	1.2%	0.0%	3.9%	2.5%
	No knowledge	Count	47	11	40	98
		%	55.3%	27.5%	26.1%	35.3%
Total		Count	85	40	153	278
		%	100.0%	100.0%	100.0%	100.0%

Results appear to be quite logical with the exemption of some of the answers provided by the RP group. One would expected less users to have competence performing straightforward tasks than to be able to perform basic tasks even without guidance.

Finally, the understanding of users regarding advanced computer aided tools are presented in table 3.4 below. The most important outcome from this part is the high percentage from all three groups

with no knowledge whatsoever. In particular, 74.0% of the MRP group have declared no knowledge, which obviously needs to be looked into, the soonest possible.

Table 3.4 Use of understanding advanced computer aided tools.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use for understanding, if applicable, advanced computer aided tools such as automatic analysis tools, CAD and AI tools.	At basic level with guidance	Count	17	13	29	59
		%	20.0%	33.3%	19.1%	21.4%
	At basic level without guidance	Count	10	7	20	37
		%	11.8%	17.9%	13.2%	13.4%
	Competent to perform straightforward tasks	Count	7	4	9	20
		%	8.2%	10.3%	5.9%	7.2%
	At advance level to perform non routine tasks	Count	4	2	14	20
		%	4.7%	5.1%	9.2%	7.2%
	At expert level to perform complex tasks and guide others	Count	2	1	6	9
		%	2.4%	2.6%	3.9%	3.3%
	No knowledge	Count	45	12	74	131
		%	52.9%	30.8%	48.7%	47.5%
Total		Count	85	39	152	276
		%	100.0%	100.0%	100.0%	100.0%

4. Digital technologies for collaboration and sharing

The fourth part of the questionnaire consisted of 3 parts which examined user's competence in Digital Technologies for collaboration and sharing.
The first part investigated whether users could use tools to apply compression on images and remove patient information from medical image data to produce anonymization. The next part examined if users could convert DICOM images to other format such as JPEG, MPEG4 etc. Finally, the fourth part of the questionnaire presented their competence in using collaboration software or shared libraries.

As can be seen in Table 4.1 below, there are certain points that need to be highlighted.

Table 4.1 Use tools to apply compression on images and remove patient information from medical image data.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use tools to apply compression on images and remove patient information from medical image data (i.e., anonymization).	At basic level with guidance	Count	22	12	62	96
		%	26.5%	30.0%	39.7%	34.4%
	At basic level without guidance	Count	11	5	23	39
		%	13.3%	12.5%	14.7%	14.0%
	Competent to perform straightforward tasks	Count	16	8	7	31
		%	19.3%	20.0%	4.5%	11.1%
	At advance level to perform non routine tasks	Count	5	3	14	22
		%	6.0%	7.5%	9.0%	7.9%
	At expert level to perform complex tasks and guide others	Count	0	3	10	13
		%	0.0%	7.5%	6.4%	4.7%
	No knowledge	Count	29	9	40	78
		%	34.9%	22.5%	25.6%	28.0%
Total		Count	83	40	156	279
		%	100.0%	100.0%	100.0%	100.0 %

Regarding technologies and tools of collaboration and sharing, a significant percentage of all categories of employees, ranging between 40% and 55%, are at the basic level and are not able to carry out straight forward tasks. It is important to note that also a large percentage of the group of the most related professionals, about 25%, appear to have no knowledge in this area. Finally, the results show that in this group of professionals the employees either deal with the relevant technologies at an advanced and expert level or remain at a basic level, not able to fulfil straight forward tasks.

The next part of Q4 examined the competence of Professionals to convert DICOM images to other formats such as JPEG, MPEG4 etc.

Table 4.2 Use tools to convert DICOM images to other formats.

	Specialty	Total

			Supporting Professionals	Related Professionals	Mostly Related Professionals	
Convert DICOM images to other formats such as JPEG, MPEG4 etc.	At basic level with guidance	Count	15	12	44	71
		%	18.1%	30.0%	28.6%	25.6%
	At basic level without guidance	Count	10	8	33	51
		%	12.0%	20.0%	21.4%	18.4%
	Competent to perform straightforward tasks	Count	11	4	17	32
		%	13.3%	10.0%	11.0%	11.6%
	At advance level to perform non routine tasks	Count	9	6	13	28
		%	10.8%	15.0%	8.4%	10.1%
	At expert level to perform complex tasks and guide others	Count	1	2	11	14
		%	1.2%	5.0%	7.1%	5.1%
	No knowledge	Count	37	8	36	81
		%	44.6%	20.0%	23.4%	29.2%
Total		Count	83	40	154	277
		%	100.0%	100.0%	100.0%	100.0%

Converting DICOM images to other formats is a task for which all the professional groups exhibit similar familiarity rates on performing straight forward tasks. Particularly the groups of RP and MRP present a remarkably similar compedence profile as regards these tasks. Finally, it is obvious that the rate corresponding to straight forward tasks competency is much lower than satisfactory as it lies between 10-13%.

The last issue examined in Q4 was the competence of using collaboration software or shared libraries.

Regarding the tools used for collaboration or shared libraries, the cognitive profile of the three professional groups seems to be similar. This finding can be considered as expected taking into account that the interest in collaboration and shared libraries is present for all professional groups. A significant percentage of employees in the group of the most relevant professions, about 40%, appear to have no knowledge of the subject at all. This percentage is much higher than the corresponding of the other two professional groups. This may be due to the fact that the former are required to use

much more specialized tools and share more specialized information, (i.e radiology images), than the latter, which may be satisfied with simpler and more common collaboration tools and sharing tools.

Table 4.3 Use of collaboration software or shared libraries.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use collaboration software or shared libraries.	At basic level with guidance	Count	21	11	32	64
		%	25.6%	26.8%	21.1%	23.3%
	At basic level without guidance	Count	12	8	21	41
		%	14.6%	19.5%	13.8%	14.9%
	Competent to perform straightforward tasks	Count	13	7	10	30
		%	15.9%	17.1%	6.6%	10.9%
	At advance level to perform non routine tasks	Count	9	8	21	38
		%	11.0%	19.5%	13.8%	13.8%
	At expert level to perform complex tasks and guide others	Count	5	2	6	13
		%	6.1%	4.9%	3.9%	4.7%
	No knowledge	Count	22	5	62	89
		%	26.8%	12.2%	40.8%	32.4%
Total		Count	82	41	152	275
		%	100.0%	100.0%	100.0%	100.0%

5. Database management

The fifth question examined the competence of users in database creation. Use of data types, including constraints, checks, tables, views, indexes, queries with join and subqueries. Table 5.1 present answers given.

Table 5.1 Database creation.

			Specialty			
			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Database creation. Use of data types, constraints, checks, tables, views, indexes, queries with join, subqueries.	At basic level with guidance	Count	21	16	46	83
		%	25.0%	39.0%	30.1%	29.9%
	At basic level without guidance	Count	10	4	18	32
		%	11.9%	9.8%	11.8%	11.5%
	Competent to perform straightforward tasks	Count	13	4	15	32
		%	15.5%	9.8%	9.8%	11.5%
	At advance level to perform non routine tasks	Count	10	4	19	33
		%	11.9%	9.8%	12.4%	11.9%
	At expert level to perform complex tasks and guide others	Count	2	5	4	11
		%	2.4%	12.2%	2.6%	4.0%
	No knowledge	Count	28	8	51	87
		%	33.3%	19.5%	33.3%	31.3%
Total		Count	84	41	153	278
		%	100.0%	100.0%	100.0%	100.0%

Approximately 60% of the combined sample from all professional groups appear to possess limited or no knowledge in database creation. This percentage may be considered as expected since these skills require time investment and are developed only when needed. This may also be the reason for the low rate (2,6%) of members of the most related professionals group at the expert level. For example physicians would assign database related tasks to other specialties rather than investinn time to develop these skills for themselves.

Table 5.2 Advanced database functions.

	Specialty

			Supporting Professionals	Related Professionals	Mostly Related Professionals	Total
Use of JSON data in a NoSQL database.	At basic level with guidance	Count	14	12	34	60
		%	16.5%	29.3%	21.9%	21.4%
	At basic level without guidance	Count	7	2	11	20
		%	8.2%	4.9%	7.1%	7.1%
	Competent to perform straightforward tasks	Count	4	4	8	16
		%	4.7%	9.8%	5.2%	5.7%
	At advance level to perform non routine tasks	Count	5	2	7	14
		%	5.9%	4.9%	4.5%	5.0%
	No knowledge	Count	55	21	95	171
		%	64.7%	51.2%	61.3%	60.9%
Total		Count	85	41	155	281
		%	100.0%	100.0%	100.0%	100.0%

As expected , the percentage of professionals that invest time to develop skills that allow independent fulfillment of tasks ranging from straightforward to expert level is extremely low, consistently below 10%, mostly around 5%. All groups present similar competence profile. It seems that the findings are driven by the fact that this type of knowledge is developed and used only when need arises.

6 Digital Big Data Analysis

The last question of the questionnaire consisted only of 1 part. How confident the users were in using MapReduce, Spark and Hive to manage large volumes of structured and unstructured data. As may be seen in Table 6.1 below, a very high proportion of those replied, 63.9%, 53.7% and 64.7% of the kMRP, RP and SP groups respectively to have no knowledge whatsoever.

Table 6.1 Use of MapReduce, Spark and Hive to manage large volumes of structured and unstructured data.

			Specialty	Total

			Supporting Professionals	Related Professionals	Mostly Related Professionals	
Use of MapReduce, Spark and Hive to manage large volumes of structured and unstructured data.	At basic level with guidance	Count	13	9	30	52
		%	15.3%	22.0%	19.4%	18.5%
	At basic level without guidance	Count	8	3	12	23
		%	9.4%	7.3%	7.7%	8.2%
	Competent to perform straightforward tasks	Count	6	3	7	16
		%	7.1%	7.3%	4.5%	5.7%
	At advance level to perform non routine tasks	Count	3	2	6	11
		%	3.5%	4.9%	3.9%	3.9%
	At expert level to perform complex tasks and guide others	Count	0	2	1	3
		%	0.0%	4.9%	0.6%	1.1%
	No knowledge	Count	55	22	99	176
		%	64.7%	53.7%	63.9%	62.6%
Total		Count	85	41	155	281
		%	100.0%	100.0%	100.0%	100.0%

The cognitive profile of the studied groups regarding the competence with big data analysis is similar to the profile recorded for the use of JSON data in a NoSQL database.
The findings indicate that big data analysis is still far from being a part of the daily routine of the studied professional groups. Indeed, only 5-7% of professionals feel able to perform straight forward tasks, whereas the expert level may well be characterized as non-existent as two of the three groups present zero of extremely close to zero rates.

Interviews

The interviews were used to capture the general and specific digital skills of the most relevant health professionals, namely Radiologists, Medical Physicicists and Radiology Technologists and identify areas for improvement and potential training needs.

The pool consists of 10 radiologists, 10 medical physicists and 10 technologists, all with professional experience between 5 - 30 years. The interviews were individual with a duration of 60-80 minutes and were based on a structured questionnaire.

The general conclusions extracted from the structured questionnaire for each group of professionals are consolidated in the following text:

Interaction with digital technologies

Radiologists generally feel confident using a variety of technologies and devices like laptops, smartphones, tablets, PCS. Nevertheless, a notable percentage would not feel comfortable trying to inter-connect these devices, install a new program or application, or do some troubleshooting without assistance.

Most technologists are comfortable with digital technologies such as laptops, smartphones, tablets, PCS. However, there are many, usually over 40, who believe that in order to use digital technologies with adequate effectiveness, more training and familiarity is needed.

Medical physicists generally seem to be comfortable with digital technologies and often appear to be capable of training others in the use of these technologies.

Use of input devices

Radiologists would be effective in using a variety of devices to input and process data. However, they would not switch from one device to another (e.g. from keyboard to voice recognition) without assistance and/or a timeframe for adjustment. In particular, the use of snippets seems to be their favorite method for medical report writing. They appreciate, when needed, additional training in using these methods in their daily routine. This seems to apply to all physicians, not only radiologists

Technologists seem to have training on the work stations and consoles they use daily. They do not appear to have sought further knowledge or training in other digital input devices. This seems to be due to the lack of access to information for this staff in their workplace. In addition, technologists seem to appreciate any method that makes their life easier in the daily routine.

Medical physicists are relatively open to new methods of text input and are generally more informed about them than other specialties. However, they do not seem to have access to these technologies in their workplace, a matter which seems to be of particular interest to them.

Use of appropriate monitor for each modality

The radiologists are generally not aware of the appropriate diagnostic monitor specifications in relation to the modality images they are dealing with. Even when they have an intuitive sense that something is not so right with their image quality, they would not think about the monitor performance or wrong monitor specifications. They are not aware of the need for regular and calibration for their monitors, but most important, they are not aware of the possible implications of working with a monitor out of specs. Although they generally work under ambient conditions that facilitate their work, they do not check these conditions against standards and diagnostic monitor specifications.
Technologists are generally unaware of the characteristics of diagnostic screens, or the environmental conditions required for diagnosis. They seem to be interested in more training on this subject.

Medical physicists seem, due to the nature of their work, to have more knowledge on this subject. A large percentage are aware of the features required on diagnostic screens used in mammography but not on screens of other modalities. They recognize the importance of this topic but often do not have the necessary equipment for practical training and are limited to what they can find in the literature.

Many have been called to seek more information following complaints from radiologists, who felt that something they were not able to define was wrong. Additional in-depth training and access to tools is needed.

Understand and use DICOM functions

Although radiologists receive training on interfaces as users, they are not at all familiar with the DICOM architecture logic, neither are they familiar with the DICOM protocols, functions and imaging data sets and management. Training at all levels is needed in this respect.
Most technologists are generally trained in the stations of the systems they use where these functions run silently. Nevertheless, they do not exhibit any deeper familiarity with these functions, let alone their ability to recognize them. More training is needed towards this direction.

Medical physicists seem to only have basic knowledge of these functions and relatively limited fluency in their use. Additionally, they do not seem to be aware of the extend of availability of software tools. Many times, for example, they prefer to save the images needed for quality control on a hard disk drive directly on the modality, rather than using DICOM tools and functions.

Understand Image Characteristics

As regards image characteristics, it appears that radiologists, technologists, medical physicists and other imaging professionals are familiar with those characteristics that affect their visual experience when assessing a medical image, like resolution. However, they have very scarce and inadequate training as regards other image characteristics and their effect in the overall performance of their systems or even in the diagnostic process, like bit depth, frame rates, image size etc. This knowledge is vital for system selection and optimized configuration.
Radiologists feel that they have adequate knowledge as regards the differences in image characteristics for different modalities. However, they believe that more training is needed for the rest of the personnel, so that they are able to contribute adequately to the optimization of diagnostic processes.

Use and understand image qualitative and quantitative analysis

Radiologists are extremely familiar and adequately trained for qualitative analysis of images but they have limited training as regards quantitative analysis, which is confined only to particular modalities. Inadequate background in digital technology creates difficulties when they have to transfer their quantitative analysis processes to a different system, especially when they try to understand the limitations of the various tools.
Medical physicists use software tools for quantitative image analysis in their daily routine. Additional training in this area would be particularly useful as it would not only extend their expertise but it would also help them understand the different options and approaches available.

Understand image characteristics

Configuration of image characteristics like contrast, filtration, spatial calibration etc. is vital for the diagnostic procedure. Luck of training may result in intuitive use of these tools without in-depth understanding of their function leading to sub-optimal image presentation and therefore diagnosis. Furthermore, inadequate training on the functionality of these tools may lead in creation of unnecessary image data sets that lead to unjustified system memory consumption.

Use 3D reconstructions and virtual processing tools

3D reconstructions and virtual processing tools are advanced options for radiologists that need in-depth training on the methods used by the different systems other than just training in the manufacturer's interface, so that they can understand the limitations and evolving possibilities when systems are upgraded or changed.
The same conclusion applies to technologists. In general, technologists are trained to use automated tools provided by imaging systems for different types of reconstructions. Nevertheless, they are not adequately trained to recognize the advantages, pitfalls and limitations or look for other possible approaches. Medical physicists have shown particular interest in these tools because in addition to their advantages in diagnosis, they can enable the development of 3D printing services. Medical physicists seem to be seeking training in this subject and in addition to be trained to export the three-dimensional reconstructions to *.stl format for 3D printing.

Use Computer Aided Diagnosis tools

Advance Computer Aided Diagnosis tools are also evolving for radiologists. It seems that radiologists in general, are familiar only with the tools that relate to the modality they use most in their daily routine, but this is not the case with other modalities. Again, in-depth training is needed so that they understand the limitations of such techniques in combination with other limitations in the diagnosis chain.
Medical physicists, on the other hand, have shown interest in training in this field to develop software tools both for research purposes and for application in the daily routine of both the diagnosis and the quality control programs.

Use of collaboration software

Image manipulation, that is, compression, anonymization, format change etc. is extremely important for professionals, taking into account the needs for data sharing, opinion sharing, scientific research as well as the contemporary legal framework on protection of patient data. These skills need to be further developed for radiologists, medical physicists and technologists so that they effectively interact with their counterparts and their digital environment in general.

Use of database tools

Database understanding and data management terminology and tools, handling of big volumes of structured and unstructured data, is a field which requires a substantial amount of time to gain and implement the necessary knowledge in the context of daily routine. To a large extend, radiologists and technologists believe that it would not be productive for their specialty to invest time mastering these techniques. Nevertheless, training for other personnel, like medical physicists, would be necessary so that they undertake these roles in a radiology department.

Medical physicists are generally interested in this field as, apart from the applications in dosimetry, is of paramount importance for data analysis and utilization by hospital administrators and decision makers. In general, all medical physicists seem to have, at some point in their careers, been asked for input on topics that require this knowledge. There are physicists who have acquired significant knowledge and experience but there are others who have no experience at all and believe that without having received some structured training, it will take significant time for a medical physicist

to be able to handle these tools effectively. Generally all physicists have shown interest in training in this field.

Discussion

Literature Review

Although an extensive literature review has been conducted using multiple methods and multiple sources such as academic databases, gray literature databases, internet research and through the websites of international organizations and organizations, the results are limited in number.

At the same time, the complexity of digital skills in the field of healthcare is recognized in the literature, especially in relation to the considerable number of digital technologies used by the various professional groups.

This complexity and the considerable number of digital technologies and applications in e-health have led to the creation and implementation of many different approaches to digital education and skill development of professionals, which in turn yield significant gaps in the cognitive background of professionals.

There is an urgent need in the literature to bridge the knowledge gaps through a planned investment for the training of professionals in a multidisciplinary approach as well as for their lifelong training in digital skills. However, the difficulty of determining the appropriate digital skills for each healthcare professional group is recognized, particularly for those groups which will have to possess a large number of skills in order to effectively perform their duties.

Survey

The survey questionnaire was conducted on three major groups of health workers taking into account the data obtained from the literature review, namely, a group of most related professionals, a group of related professionals and a group of supporting professionals. This grouping approach as well as the structure of the questionnaire itself, have been designed taking into account the information provided by the literature review.

The survey confirms the literature in relation to the existence of significant cognitive gaps in all professional groups and in all subjects related to digital skills. Our analysis shows that the knowledge gaps for the related and most related professions are mainly located between the basic level and ordinary task handling and the advanced and expert level. Moreover, for the supporting professions, the gap is mostly identified between the no knowledge level and the skills required to fulfil basic tasks. It is also found that the required knowledge and the relative extent of this knowledge in order for health professionals to effectively perform their duties, differ substantially amongst different professional groups.

Interviews

The interviews were very constructive as health professionals were given the opportunity to more easily understand the questions asked and to submit in detail their needs for the acquisition and application of digital skills.

The process of interview with professionals established the fact that digital skills are required in modern healthcare services in order not only to perform specialized tasks but also to fulfill basic daily

straightforward tasks. Furthermore, as the multidisciplinary approach has been recognized as an essential factor for quality healthcare services, collaboration and networking between professionals, even of the same specialty for additional consultation, becomes increasingly important. The development and maintenance of the required digital skills in healthcare, becomes therefore a necessity.

These interviews have in many cases identified the interest of health professionals in digital skills that they acknowledge they do not possess. In other words, it seemed that even though in their career they did not have the opportunity to acquire certain specialized digital skills, they are nevertheless able to recognize their usefulness.

In addition, interviews have shown that health professionals are able to identify digital skills which, in their view, are either not useful in everyday practice or require a disproportionate training effort in relation to the benefits of implementing this knowledge. In such cases, the need for the development and application of certain specialized digital skills only for certain groups of health professionals is recognized, who due to their academic background can put these skills into everyday practice with reasonable effort.

Conclusion

The analysis of the information collected through the research tools used in the context of this project conclude as follows:

- Digital skills are essential in modern healthcare to perform straightforward daily routine tasks, but also to promote collaboration and networking between healthcare professionals, which is vital for a multidisciplinary approach.
- For several years, tools have been developed and put into international practice, for the management of digital functions and activities in the health sector. In addition, standards and international protocols have been established for manufacturer compliance, promoting interoperability. However, the training of professionals has not been standardized in a similar manner, to achieve the required uniformity in digital skills. This fact reduces efficiency while increasing the operating costs of digital technologies, let alone the possibilities of sub-optimal diagnosis. Furthermore, inadequate training results in resources loss, and non-utilized investments in digital tools.
- The type and extent of digital skills development needs, differs amongst different professional groups. Education, training, and maintenance of digital skills should be tailored to the needs of each group. Data analysis in the context of this project, indicate that the strategic goal for digital skill development and maintenance should be adjusted to the relevance of professional groups. Hence, the strategic goal for supporting professionals should aim at moving the approximately 43% (all questions mean value) of workers with no knowledge of digital applications towards being able to perform simple tasks with or without guidance. The 52% (all questions mean value) of workers in the category of relevant professions without or with limited knowledge should be trained so that they are at least able to perform straightforward tasks. Finally, the workers in the most relevant professions should be enabled to perform at advanced and even expert level at a considerably higher rate than the approximately 9% (all questions mean value) registered in this project.
- There is a considerable number of digital skills that need to be developed amongst different collaborating professional groups, therefore, designing and providing education and training as well as maintaining the appropriate digital skills for each group becomes a complex procedure.
- Therefore, healthcare professional groups should receive standardized trainings, and their skills should be continuously updated through a certification process.
- The provision of standardised training requires central management to achieve uniformity across Europe.

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