ADAPTING ACQUISITION PROTOCOLS FOR COVID-19 PATIENTS: A RADIOGRAPHERS' PERSPECTION IN ITALY.

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ABSTRACT

Introduction
Radiology departments played a crucial role during the coronavirus disease 2019 (Covid-19) pandemic providing imaging to help physicians managing the infected patients. This scenario affected healthcare workers (HCWs) during their daily activities. Therefore, the scope of this study was to evaluate the operating procedures, the acquisition protocols for x-ray and CT examinations for infected patients and the implementation of Artificial Intelligence (AI) software during the Covid-19 pandemic.

Materials and methods
This survey was designed by some Italian scientific associations of radiographers. The questionnaire was administered via social media, the targeted population was all the HCWs working within the Radiology Departments in Italy and the questionnaire was available online from January to March 2022. Demographic and epidemiological data, number of radiographers, x-ray and CT methods of investigation, protocols used in x-ray and / or CT and Artificial Intelligence software applied in the radiology department were the sessions of the survey.

Results
Comparisons between participants that work in public versus private healthcare facilities were carried out using chi-square tests and Fisher tests. The responders were 1376 and 73.7% of them worked in public healthcare facilities. Private healthcare facilities had fewer CT scanners available in general ($p < 0,001$), hence only 18% of them affirmed to have 2 or more CT scanners, and not have CT scanners dedicated to confirmed or suspected Covid-19 patients only ($p < 0,001$). 66.3% of the participants stated that only one radiographer was involved in the execution of portable CXR (chest x-ray) for infected patients.

Conclusions
This survey highlighted how radiographers adjusted their acquisition protocols when it came to acquire portable or standard CXR and chest CT scans for infected patients over the different waves of the Covid-19 pandemic. Using dedicated equipment, adopting tailored scanning protocol and implementing AI software were the main strategies applied.

INTRODUCTION

Radiology departments played a crucial role during the coronavirus disease 2019 (Covid-19) pandemic providing imaging to help physicians managing the infected patients [1,2] and this impact affected healthcare workers (HCWs) during their daily activities. Italy was the first hit of the pandemic in Europe back in February 2020. Since then, the HCWs within the Radiology Department had to change and adapt themselves to better treat their patients. Designing new pathways, drawing operative instructions, creating new acquisition protocols for suspected of infected patients in conventional radiology (x-ray) and Computed Tomography (CT) or implementing Artificial Intelligence (AI) software to quantify the extent of Covid-19 related pneumonia were the main tasks to address during the different pandemic waves. Therefore, the scope of this study was to evaluate the operating procedures, the acquisition protocols for x-ray and CT examinations for infected patients and the implementation of AI-based software during the Covid-19 pandemic.

MATERIALS AND METHODS

Study design

The institutional review board (IRB) issued its approval for this study, which was designed by some Italian scientific associations of radiographers, such as AITeRTC (Italian Association of CT Radiographers), ASIMS (Association of Health Imaging Service), AI-

TASIT (Italian Association of Radiology System Administrator and Telemedicine), GReSS (Risk Management in Healthcare), and supported by the Italian Federation of Scientific Radiographer Societies (FASTeR). The survey was administered via social media using a Google Forms link (Google, Mountain View, California, USA) and all the participants were asked to give their informed consent. The targeted population was all the HCWs working within the Radiology Departments in Italy and the questionnaire was available online from January to March 2022. 4 area of interest (sessions) were highlighted in the survey: demographic and epidemiological data, number of radiographers, x-ray and CT methods of investigation, protocols used in x-ray and / or CT and Artificial Intelligence software applied in the radiology department. Sessions of the questionnaire are summarized in table 1.

n	Sessions
1	Demographic and epidemiological data
2	Number of radiographers, x-ray and CT methods of investigation
3	Protocols used in x-ray and / or CT Artificial Intelligence software applied in the radiology
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Table 1 *sessions of the survey*

The survey was drafted in accordance with the Checklist for Reporting Results of Internet E-Survey (The CHERRIES statement) [3] and a pilot test group was used to verify the feasibility and appropriateness of the survey [4]. The participants were informed that the data they provided would have been managed anonymously for research purposes only and archived in adherence with data protection requirements.

RESULTS

Demographic data

Participants' median age is 35-45 years, 51.9% of them were male and 47.9% were male. The number of the total responders was 1376 and 88,4% of those were represented by radiographers. The other HCWs were represented by nurses (0.3%), coordinator radiographers (10.2%) and academic HCWs (0.4%). 73.7% of the participants worked in public healthcare facilities and 87.1% have a full-time contract in their departments. Participants' median years of experience is >10 years. The whole demographic data are listed in table 2.

Statistical analysis

All the data gathered through the survey are displayed in the attachment 1. Comparisons between participants that work in public versus private healthcare facilities were carried out using chi-square tests and Fisher tests. All statistical analyses were performed using SPSS Statistics (IBM, v29). Private healthcare facilities had fewer CT scanners

	N (%)
Age group (years)	
<25	55 (4)
26-35	418 (30.4)
36-45	259 (18.8)
46-55	381 (27.7)
56-65	248 (18)
>65	15 (1.1)
Gender	
Males	659 (47.9)
Femals	714 (51.9)
Years of experience	
0-1	49 (3.6)
1-5	257 (18.7)
6-10	149 (10.8)
>10	921 (66.9)
Are you currently employed?	
yes	1363 (99.1)
no	13 (0.9)
What role do you play within the radiology Deparment?	
Radiographers	1217 (88.4)
Coordinator	141 (10.2)
HCWs in University	6 (0.4)
Nurse	4 (0.3)
Other	8 (0.6)
What type of healthcare facility do you work for?	
Public	1014 (73.7)
Private	292 (21.2)
Research Institute	70 (5.1)
Working hours profile	
Full time	1198 (87.1)
Part time	99 (7.2)
Free lancer	79 (5.7)

Table 2 *demographic data*

available in general ($p < 0,001$), hence only 18% of them affirmed to have 2 or more CT scanners, and not have CT scanners dedicated to confirmed or suspected Covid-19 patients only ($p < 0,001$). When dealing with examination protocols, it must be mentioned that public healthcare facilities, when compared to private ones, appeared to differ upon exa-

mination protocols: public facilities are more incline to have a chest CT protocol dedicated to patients with suspected or known SARS-CoV-2 infection ($p < 0,001$) and a higher number of radiographers involved in performing portables chest x-ray ($p < 0,001$).

Questions	Answers	%
In a dedicated COVID-19 x-ray room, how many radiographers are involved in performing a chest x-ray?	1 2 other	45.6 411.8 12.6
Has this changed from the first wave?	yes no	14 86
How many radiographers are involved in carrying out a portable chest x-ray in another ward?	1 2	66.3 33.6
Has this changed from the first wave?	yes no	15.6 84.4
In a dedicated COVID-19 scan room, how many professionals are involved in performing a CT scan?	1 radiographer 2 radiographers 1 radiographer and other HCW	20.4 45.1 34.4
Has this changed from the first wave?	yes no	14.5 85.5
In your facility, is there a dedicated pool of radiographers who only works with COVID-19 patients?	yes no I don't know	11.4 85.8 2.8
Is there a chest CT protocol dedicated to patients with suspected or known SARS-CoV-2 infection?	yes no I don't know	45.6 45.5 8.9
If so, what changes from the standard protocol?	exposure control collimation kernel and/or display window reconstruction thickness pitch kV and/or mAs use of contrast agent HRCT	23.7 5.2 9.6 9.6 7 10.2 9.7 56.3
Where are x-ray investigations performed for patients with suspected or known SARS-CoV-2 infection?	in the ward in the x-ray room both	24 25.7 50.3
Regarding a portable x-ray on a patient with known SARS-CoV-2 infection, is there a dedicated mobile X-ray unit?	yes no I don't know	57.6 31.4 11
Since the beginning of the pandemic, have artificial intelligence software been implemented for post-processing?	yes yes, but they are not used no I don't know	7.9 1.4 71.1 19.6
If yes, how often are they used?	always very often a little never I don't know	
If so, in which field are they used?	lung oncology virtual colonscopy cardio other I don't know	13.2 2.8 2 2.7 19.9 67.9
Which operator performs the post-processing analyzes?	radiographer radiologist other	60.5 40.3 20.5

Attachment 1

DISCUSSION

Several authors published regarding the extent of the impact of the Covid-19 pandemic within the Radiology departments all over the world. Martini et al [5] suggested the importance of designing two different pathways for infected and non infected patients. This significatively reduces the risk of cross-infections between patients and HCWs. Herpe et al [6] assessed the compliance and the impact of the Covid-19 RSNA recommendations (Radiology Societies of North America) in France through an online survey sent to 40 radiology departments in between March and April 2020. It resulted that all the centers in this study reshaped their practices during the pandemic: they increased the remote reporting for radiological examinations, although it appeared to be insufficient due to a lack of time to mobilize the resources needed, dedicated CT scanners for Covid-19 patients were widely available, while this was not the case for US (ultrasound), general radiography and MRI (Magnetic Resonance Imaging) and frequently a Covid-19 trained member of staff working exclusively with infected patients was not achievable. Regarding the variations on CT protocols for Covid-19 patients, Homayounieh F et al [7] discussed this matter through a survey issued by the International Atomic Energy Agency (IAEA) from May to July 2020. The questionnaire collected data from 62 healthcare sites in 34 countries. It was about scan parameters, dose-related information, having a dedicated CT protocol for Covid-19 patients, how many CT scanners were available in the facility and which type of CT protocol was the most used for this type of patients. This survey showed that half of sites had dedicated CT protocol. 67% of the facilities used noncontrast chest CT and 20% of them used a reduced-dose protocol compared to the routine. Moreover, this paper highlighted that scanners with more than 64 detector rows were associated with lower dose in terms of CTDIvol (Volume CT Dose Index) and DLP (Dose Length Product), alongside enabling the use of iterative reconstruction compared with conventional filtered back projection. The statistical analysis of this study pointed out that there are strong differences in between public and private healthcare facilities, such as public facilities appear to be better prepared from an organizational point of view than private facilities. This could be explained since they have a broader and more defined experience on the management of infectious diseases and the diagnostic therapeutic care pathways to be followed in those cases. As suggested by Martini et al [8], having a suitable designed scenario with two different pathways helps to reduce and avoid cross-infections between patients and healthcare workers. With respect to risk management and patient safety, 41.8% and 45.6% of the respondents said that they have respectively one and two radiographers involved in performing a chest x-ray (CXR) for a Covid-19 patient. Following this data, 66.3% of the participants stated that only one radiographer is involved in the execution of portable CXR for infected patients. The two-radiographer approach, one managing the infected patients and the other one performing the examination, significantly reduces the risk of cross-infection as stated in the document “Appropriate and safe use of Medical Imaging and Radiation Therapy with infection control measures considered in addition to standard radiation protection procedures” [9] issued by the International Society of Radiographers and Radiation Technologists. Moreover, the analysis regarding the existence of a specific tailored chest CT protocol for patients affected by Covid-19 ($p < 0,001$) displayed that almost half of the participants used a specific CT acquisition protocol and it was different from the standard one in terms of exposure factors, dose and use of HRCT (High Resolution CT) technique depending on the CT scan vendor. The results showed that 70% of private facilities had no specific tailored CT acquisition protocols. These results seem to be in accordance with Suliman I.I et al [10], which compared 10 studies implanting ultra-low-dose chest CT protocol. It appeared that decreasing tube voltage, using filter to reshape the x-ray beam and cut off the lower energies (such as tin or silver filter), implementing iterative reconstruction algorithms and adapting mA range or even the adoption of mAs fixed lead to significant radiation dose decrease. In this current study, 23,7% of the respondents stated that the dedicated Covid-19 chest CT protocol differed from the standard by radiation dose, kV and mAs (10.2%) and by using a high resolution CT (HRCT) protocol (56.3%). Atli E. et al [11] confirmed that a low-dose chest CT protocol intended for Covid-19 pneumonia did not affect the image quality or the diagnostic confidence. Additionally, regarding dedicated portable x-ray machine for CXR on patients with Sars-Cov-2 infection, statistical relevance (p value $< 0,001$) was recorded. This scenario was mainly available in public facilities and this might be explained as a financial aspect due to a broader monetary budget available. Furthermore, this survey highlighted that just a small part of the respondents had been implementing AI software for post-processing. In this regard, Kuo MD et al [12] validated an AI model to predict the Sars-Cov-2 infection on CXR in symptomatic patients, as well as Chaudhry, H.A.H. et al [13] issued a valid AI tool for lung nodule segmentation on chest CT scans. In particular, public facilities seemed to use more frequently this tool (p value 0,018) and, according to this survey, had been mostly used in cardiac examinations, virtual colonoscopy and lung fields examinations performed mainly by radiographers to assess lung parenchyma, as mentioned by Risoli et al [14], who made a comparison between the involved lung parenchyma score obtained out of three different software and a radiological score.

LIMITATIONS

This study presents few limitations. The radiographer populations estimation is about twenty-eight thousand, therefore the number of the total responders, 1376, might not be as representative as possible. The reason for that may lay on the fact of the time-consuming filling process for the survey. Overall, public healthcare facilities provided much more data compared to the ones coming from the private ones.

CONCLUSION

This survey highlighted how radiographers adjust their acquisition protocols when it came to acquire portable or standard CXR and chest CT scans for infected patients over the different waves of the Covid-19 pandemic. Using dedicated equipment, adopting tailored scanning protocol and implementing AI software were the main strategies applied.

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