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The Impact of COVID-19 on Nuclear Medicine in Europe

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The COVID-19 pandemic has profoundly changed hospital activities, including nuclear medicine (NM) practice. This review aimed to determine and describe the impact of COVID-19 on NM in Europe and critically discuss actions and strategies applied to face the pandemic. A literature search for relevant articles was performed on PubMed, covering COVID-19 studies published up until January 21, 2021. The findings were summarized according to general and specific activities within the NM departments. The pandemic strongly challenged NM departments: a reduction in the workforce has been experienced in almost every center in Europe due to personnel diagnosed with COVID-19 and other reasons related to the coronavirus. NM departments introduced procedures to limit COVID-19 transmission, including environmental and personal hygiene, social distancing, rescheduling of non-high-priority procedures, the correct use of personal protective equipment, and prompt identification of suspect COVID-19 cases. A proportion of the departments experienced a delay in radiopharmaceuticals supply or technical assistance during the pandemic. Furthermore, the pandemic resulted in a significant reduction of diagnostic and therapeutic NM procedures, as well as a reduced level of care for patients affected by diseases other than COVID-19, such as cancer or acute cardiovascular disease. Telemedicine services have been set up to maintain medical assistance for patients. COVID-19 pandemic has reshaped human work resources, patient's diagnostic and therapeutic management, operative models, radiopharmaceutical supplies, teaching, training and research of NM departments. Limits of availability of resources emerged. Nonetheless, we have to provide continuity in care, especially for fragile patients, maintaining infection control measures. Challenges that have been faced should reshape our vision and get us prepared for the future.

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Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the etiological agent of coronavirus

disease 2019 (COVID-19), has affected patients globally in a pandemic.¹ To date, there have been more than 150,000,000 cases with more than 3,000,000 deaths.² The COVID-19 pandemic has profoundly changed the organization of hospital activities, including nuclear medicine (NM) practice. Healthcare systems have been strongly challenged, and limits of availability of resources emerged. Several studies have evaluated the impact of the pandemic on different NM departments, the majority of which focused on specific countries or specific fields of NM.

This review aimed to determine and describe the impact of COVID-19 on NM in Europe, based on a review of the literature published in the first year of the pandemic, and to critically discuss the actions and strategies applied to face the pandemic.

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Methods

Eligibility Criteria, Search Strategy, and Study Selection

We performed a comprehensive literature search for relevant articles on the impact of COVID-19 on NM practice published up until January 21, 2021, using the PubMed database. We did not apply any other limitation on the publication date. The search strategy combined terms (text words) referring to "COVID-19" and "Nuclear Medicine". Specifically, the following search strategy was applied: "SARS-CoV-2" OR "COVID-19" OR "coronavirus" AND "nuclear medicine" OR "positron emission tomography" OR "PET". Exclusion criteria were: duplicates, non-English language papers, non-human studies, corrections, and studies outside the field of interest. Subsequently, we screened the reference list of selected studies to identify additional eligible articles. Two authors (ST and MK) independently evaluated the papers. Screened articles were included in the review when considered eligible by both reviewers. In case of discrepancies between the 2 reviewers, papers were discussed to reach a consensus.

Results

Study Selection

The search retrieved 470 records; after removing duplicates and initial screening of titles and abstracts, 425 publications were excluded, and the remaining 45 were selected to be retrieved in full text. Subsequently, 2 papers were excluded (1 outside the field of interest and 1 that could not be accessed). The selection process is summarized in [Figure 1](#). The final 43 relevant articles that we included comprised 17 editorials/letters to the editor/commentaries, 13 guidelines/recommendations, 6 original articles, 4 surveys, 1 mini-review of surveys, 1 interview, and 1 review. We summarized the findings according to general and specific activities within the NM departments covered in these articles.

Organizational Changes

The pandemic influenced workflows in a substantial proportion of NM departments. From the global survey by Freudenberg et al, 15% of the respondent departments modified working hours for less than 20% of the staff (short term contracts, part-time, or staff turnover); the work schedule has been modified by between 20% and 70% in 26% of departments, and 18% of departments modified the working hours of their staff by more than 70%. Staff transfer to other departments occurred in 34% of the institutions.³ Some centers established rotations to put in place backup teams.⁴ Similarly, the international survey by Annunziata et al reported that few sites (36/220, 16%) were closed or shifted to assist the treatment of COVID-19 patients. In some departments, professionals from NM moved part-time or full-time to assist patients with COVID-19 (76/220, 44%). Few centers performed low-dose computed tomography (CT) integrated into single-photon emission computed tomography (SPECT) and positron emission tomography (PET) scanners for screening for COVID-19 patients (23/220, 10%).⁵ In United Kingdom (UK), 8% of respondents reported efficiently using CT on SPECT/CT scanners to support radiology departments; an additional 17.7% of respondents were considering taking this step.⁶ Maffione et al reported a change in departmental organization for appointment booking, with departments requesting a recent negative SARS-CoV-2 swab from patients scheduled to undergo inpatient procedures. Additionally, they extended operating hours (from 7 a.m. to 10 p.m.) 7 days per week a recent negative swab was requested for inpatient procedures. Additionally, they extended operating hours (from 7 a.m. to 10 p.m.) 7 days per week.⁷

Impact on the Workforce

Freudenberg et al reported that 15% of respondents experienced SARS-CoV-2 infections among professionals within their departments: 12% reported that less than 20% of staff were infected, whereas 2.5% reported infection rates between 20% and 40%, and 0.5% observed high rates between 40%

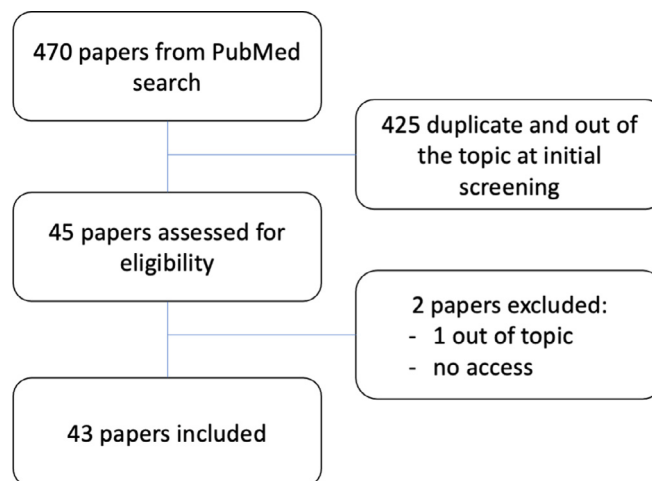


Figure 1 Paper selection workflow.

and 60%. Most of these reported infections occurred in Italy and Spain (28%).³ At the time of the response to the survey by Annunziata et al, at least one NM physician and another healthcare professional were diagnosed with COVID-19 in 54/220 (23%) and 80/220 (36%) departments, respectively.⁵ In the UK, 85% of NM departments worked with a reduced workforce: 46.3% of staff have been deployed to different roles or re-deployed within their Trusts (organizational units of the National Health Service [NHS] in the UK). Reasons for staff absence from work included COVID-19 positive cases, staff with COVID-19-like symptoms but negative SARS-CoV-2 PCR swab tests, self-isolations due to family members' COVID-19 symptoms, stress-related illness, burnout, and illnesses unrelated to COVID-19.⁶

By contrast, in a study focusing on telemedicine to assist outpatients, Klain et al reported that the 2 referring physicians, 3 residents and 1 nurse who were usually involved in in-ward consultations at the center they studied, were not reduced in number during the pandemic. Indeed, the teleconsultations implemented during the pandemic involved a significant workload, requiring approximately 30-40 minutes per teleconsultation, while the meantime for an in-ward consultation was 15-25 minutes.⁸

Standardized Operating Procedures, Hygienic Measures, and Prioritization

According to the results of the British Nuclear Medicine Society (BNMS) COVID-19 survey, 97% of NM departments introduced procedures to limit SARS-CoV-2 transmission; at 68% of sites, standardized operating procedures were developed for running departments in pandemic situations.⁶ Numerous recommendations and commentaries have been published to advise NM facilities on implementing measures to limit the spread of SARS-CoV-2 infection. These recommendations include environmental and personal hygiene, social distancing, rescheduling of non-high-priority procedures, the correct use of personal protective equipment (PPE), and prompt identification of suspect COVID-19 cases.^{4,9-12} Moreover, recommendations and editorials on the clinical management of patients undergoing diagnostic and therapeutic procedures in NM departments have been published.¹³⁻²⁰

Availability of PPE

In April 2020, during the pandemic peak, 50% of the participants in an international survey reported a shortage of PPE.³ Stockpiles of PPE were expected to last for only 1 month in 83% of centers, with no significant differences across geographic regions.³ Almost all departments ensured proper distancing and use of PPE, such as surgical masks and gloves, for staff and patients (200/220, 91%). Specifically, 191/220 (87%) departments provided surgical masks for NM staff, and 141/220 (64%) departments provided surgical masks to all the patients.⁵ However, 48% of the respondents from NM services in Germany, Austria and Switzerland reported a shortage of PPE.²¹ According to the report from the UK,

64.9% of BNMS members had PPE readily available, 18.2% had PPE most of the time, 5% of members had PPE only sometimes, and 2.6% had no PPE available in the first-wave period of the pandemic, with regional variabilities in the availability of PPE being reported.⁶ Maffione et al reported that NM staff were offered continuous training on prevention and control of COVID-19, including the correct use of suitable PPE. Healthcare workers were monitored by both swab and serology tests. The Veneto region in north-eastern Italy scheduled a test every 10 days staff in for high-risk categories and every month for low-risk ones.⁷

Radiopharmaceutical Demand and Supply

According to an international survey in April 2020, in line with the reductions of activity in NM departments, 50% of respondents reduced their orders of technetium-99m/molybdenum-99 (^{99m}Tc/⁹⁹Mo) generators. Specifically, while 12% maintained their orders for more than 70% of their regular demand, 25% of sites maintained 20%-70% of their orders, 13% maintained less than 20% of their orders, and 12% cancelled their generator orders entirely. European centers did not experience significant disruption in supplies of radioisotopes, generators, and kits.³

Conversely, Annunziata et al reported that a proportion of departments experienced a delay in radiopharmaceuticals supply or technical assistance during the pandemic (92/220, 42%).⁵ The BNMS survey reported that 81% of participants did not experience any problem with radiopharmaceutical supply, 13.9% had occasional problems, and 5.1% experienced disruptions to supply.⁶

Use of Communication Technologies

In the study by Klain et al, which focused on managing thyroid cancer patients at a center in Italy, 445 telemedicine visits were performed during the pandemic. Consequently, only 80 (15%) of outpatient evaluations were missed compared with the corresponding period of 2019 during which in-ward access was available (n=525)(8).

From a survey focused on the management of patients with neuroendocrine neoplasms (NENs) during the pandemic (COVINET), it emerged that most of the 24 responding centers (21, 87.5%) used telemedicine for follow-up visits of these patients, which were conducted by phone, video calls, email or instant messaging.²² Operational modifications reported in the survey by Freudenberg et al included the adoption of online conferences (57%), online reporting (26%), and video consultations for patients and referring physicians (26%).³ Panzuto et al reported that the activity of multidisciplinary teams was maintained in 19 (79.2%) of sites; however, the medium of discussion was changed in 12 centers (50%), switching from physical meetings to web-based virtual meetings. In 5 centers (20.8%), multidisciplinary team activity was suspended.²²

Impact on Clinical Trials

The slowing of the imaging workflow has also affected imaging related to the participation of patients in oncological trials.²³ From the COVINET survey it emerged that 12 of 24 centers (50%) reported having interrupted patients' enrollment in clinical trials or having delayed activating new planned clinical trials.²²

Impact on Outpatient Visits

According to the survey by Freudenberg et al, there was a median 50% decrease in outpatient visits in April 2020. The center-based analysis demonstrated a mean decrease of 21% in the proportion of outpatients and a median decrease of 20%.³ In the COVINET survey, most institutions (70.8%) reported modifying the follow-up modality for patients with neuroendocrine tumors. In particular, in 1 center, outpatient visits and hospitalizations were stopped, while in 16 centers (66.7%), they were reserved for urgent clinical conditions. The remaining 7 centers (29.2%) continued their everyday activity.²²

Impact on Diagnostic and Therapeutic Activity

Respondents to the survey by Freudenberg et al reported a mean decline of 54.4% in diagnostic procedures. In particular, PET/CT scans decreased by a mean of 36%. Thyroid scans decreased by 67%, myocardial studies by 66%, bone scans by 60%, lung scans by 56%, and sentinel lymph node procedures by 45%.³ Annunziata et al found that approximately all departments changed their quantitative scheduling workflow (213/220, 97%): diagnostic and therapeutic procedures were maintained but quantitatively reduced in half of the departments (112/220, 51%). Conventional scintigraphy and SPECT imaging resulted in being the most affected (155/220, 70%), particularly nuclear cardiology examinations (58/220, 26%).⁵ Nearly all (97%) participating centers in the survey from Germany, Austria and Switzerland reported a decline in diagnostic NM procedures. The mean change for PET/CT was -14.4%, while there were significant reductions for bone, myocardium, lung, thyroid, and sentinel lymph-node scans (-47.2%, -47.5%, -40.7%, -58.4%, and -25.2%, respectively).²¹ Similarly, Maffione et al reported a significant reduction in the number of examinations (comparing March and April 2020 with the corresponding period of 2 months in 2019), with the prominent decrease (31%) being in scintigraphy and SPECT examinations. In contrast, there was a decrease of just 4% in PET/CT scans.⁷ In a center located in an area with a low prevalence of COVID-19, Maurea et al reported that the number of [¹⁸F]FDG-PET/CT studies performed during the pandemic (n = 299) and in the corresponding period of 2019 (n = 335) were comparable (P = 0.74).²⁴ In NHS England PET-CT services, the turnaround time for [¹⁸F]FDG PET-CT scans did not increase (indeed, the percentage of scans with a turnaround time of more than 7 working days during April and May 2020 was

lower than that in the same months in 2019). Overall, these PET/CT services maintained their ability to meet demand.²⁵

Myocardial Perfusion Imaging

Nuclear cardiology was one of the most affected branches of NM during the COVID-19 pandemic, above all in reducing the number of examinations.⁵ All non-urgent examinations were postponed according to priority scales considering, for example, the level of cardiologic risk.²⁶ A prioritization strategy for scheduling stress myocardial perfusion scintigraphy has been developed by Scrima et al. A total of 46 patients affected by chronic ischemic cardiopathy underwent stress myocardial perfusion scintigraphy. The patients were labelled as B category according to the following criteria: the presence of symptoms (undefined dyspnea and/or pre-cordial pain) associated with one or more clinical parameters, mainly if associated with diabetes and reduced ejection fraction. The patients were labelled as D category when asymptomatic but had at least 2 positive clinical parameters. Overall, 9/46 patients (19.6%) had moderate inducible ischemia (5 B-category and 4 D-category; 3 of the latter group had diabetes). Using the stratification approach, the incidence of significant inducible ischemia increased to 19.4%, compared with 7.69% during the same period in 2019. These data support the categorization of patients based on clinical urgency to assign priorities.²⁷ Telemedicine helped in the initial evaluation and monitoring, which took place remotely, of cardiology patients in different scenarios such as preventive cardiology, hypertension, rhythm disorders, heart failure and nuclear cardiology.²⁸ The use of this modality also permitted an initial evaluation of patients with possible COVID-19 symptoms or COVID-19 positive contacts.²⁹ When patients were admitted to NM departments for nuclear cardiology examinations, rapid protocols and pharmacological stress examination instead of exercise test were preferred. Furthermore, to prevent infection transmission, reusable materials and rooms were sanitized, leading to lengthening of intervals between patients and lengthening of the working day.^{26,30}

After the examination, special attention was paid to check lung findings from SPECT and PET/CT examinations, and the use of dematerialized files and reports was encouraged.²⁶ Finally, to reduce the risk of SARS-CoV-2 transmission, alternative methods of communication for multidisciplinary cardiology meetings, such as video conferencing, were considered.³¹

Lung Perfusion/Ventilation Imaging

Pulmonary embolism and COVID-19 lung infection symptoms may overlap, and pulmonary embolism may be a common finding in COVID-19 patients.³² In patients with suspected pulmonary embolism, in order to preserve the diagnostic quality of NM examinations and to avoid unnecessary risks related to aerosol production, the difficulty of disinfecting ventilation systems and the proximity of healthcare personnel during the procedure, perfusion-only scintigraphy of the chest was performed, with the exclusion of ventilation scans. Furthermore, the addition of low-dose CT to the

SPECT images achieved an increase in the sensitivity of the procedures for detecting abnormalities. However, ventilation SPECT scans may still be performed in patients whose lung perfusion scan is abnormal after COVID-19 testing of the patient and with the use of appropriate PPE for aerosol-producing procedures.³² Even in this scenario, appropriate attention must be paid to checking the lung findings from SPECT examinations.

Brain Imaging

Although it has been reported that SARS-CoV-2 infection can cause neurological involvement such as encephalitis, olfactory dysfunction, or thrombotic events, the pathophysiological processes that cause these types of damage are not fully known.³³

Neurological features of COVID-19 should be considered by NM physicians when evaluating patients who undergo neurological NM examinations. Furthermore, patients with neurological diseases may be more vulnerable if they cannot follow proper social distancing or use PPE and are therefore at higher risk of infection.^{33,34} The workflow of many NM units was modified during the pandemic to favor more urgent examinations, which has resulted in a significant reduction in the number of brain PET and SPECT examinations in patients with chronic neurological diseases.³⁵ Another negative consequence of the pandemic for patients with neurological diseases is the interruption of clinical trials using brain PET.³⁵

PET/CT Imaging

A decrease in 32% and 31% of activity was observed in NHS England PET/CT services in April and May 2020, respectively. Non-oncologic [¹⁸F]FDG-PET/CT scanning was the most seriously affected, with decreases of 55% and 33%, respectively, during April and May 2020. Oncology scanning decreased by 23% and 26% in the 2 months. In particular, the percentage decrease was most marked for esophageal cancer and lung cancer. In June 2020, when [¹⁸F]FDG PET/CT scanning activity related to melanoma and lymphoma had returned to the previous year's performance, lung and esophageal cancer still reported a 23% and 26% decrease in activity the previous year. PET/CT examinations for diagnosis and staging of lung cancer showed a fall of 29% in April, 47% in May, and 26% in June 2020 relative to 2019. For lymphoma, which showed the less relevant dip, the decrease was 9% in April, 28% in May, and 14% in June 2020.²⁵ These results are in line with those that emerged from the BNMS survey, which 138 members completed. A mean reduction in PET/CT scanning activity of 32% was reported, which was the least-affected diagnostic procedure.⁶ During the pandemic, few NM departments reported being directly involved in screening or assisting COVID-19 patients. In many NM departments, measures to contain the spread of SARS-CoV-2, such as patient triage including clinical evaluation and temperature scanning or postponing non-urgent examinations, were undertaken. Despite these precautions, cases of SARS-CoV-2 infection, which were negative on clinical

evaluation, were detected incidentally by [¹⁸F]FDG-PET/CT.³⁶⁻³⁸ The role of PET/CT in the management of COVID-19 is still unclear, and further studies are needed to define its role. However, it is crucial to pay particular attention when incidental lung findings are highlighted on a PET/CT scan, and if these findings are consistent with or highly suspicious for the presence of an active COVID-19 infection, they must be immediately reported.⁵

Impact on Molecular Radionuclide Therapies

Freudenberg et al reported that 81% of responding sites performing radionuclide treatments had a mean service reduction of 45% in April 2020. Departments reported reductions by a mean of 47% in radioiodine (RAI) therapy for thyroid cancer, 63% for benign diseases, 43% in radiosynovectomies, 40% in selective internal radiation therapy, of 38% in peptide receptor radionuclide therapy (PRRT) and of 38% in prostate-specific membrane antigen radioligand therapy.³ In Germany, Austria and Switzerland, 76% of the survey participants reported a reduction in radionuclide therapies, especially for benign thyroid disease (-41.8%) and radiosynoviorthesis (-53.8%); by contrast, the number of cancer therapies remained primarily stable.²¹ Similarly, in the survey by Annunziata et al, RAI therapy showed the most significant reduction among the radionuclide therapy procedures.⁵ In the UK, an overall reduction in radionuclide therapies was reported. Specifically, RAI treatment for thyroid cancer was reduced by a mean of 69%, while RAI treatment for benign thyroid disease was reduced by 77% (range 52.6%-100%). By contrast, [²²³Ra]Ra-dichloride treatment, neuroendocrine tumor treatment, and selective internal radiation therapy experienced relatively modest reductions of 13%, 16%, and 8%, respectively.⁶

Thyroid Imaging and Therapy

Most patients with differentiated thyroid cancer (DTC) are not at increased risk of developing critical COVID-19 complications; however, cancer patients, in general, have a higher risk of mechanical ventilation, ICU admission or death.³⁹ As mentioned above, RAI had the most evident reduction among the therapy procedures.⁵ RAI procedures for benign conditions were postponed when possible, leading to an even higher reduction in these treatments than RAI for thyroid malignancies. In addition, patients scheduled for an examination after total thyroidectomy for DTC before or after RAI therapy were offered alternatives such as telemedicine consultations.¹³

In 1 center, DTC patients who had undergone total thyroidectomy were evaluated before or after RAI therapy with telemedicine (eg, phone calls, faxes, emails). If the attending physician, after a teleconsultation, indicated that a more detailed assessment was necessary, patients were offered an in-ward consultation, at which all measures necessary to prevent the spread of COVID-19 were employed. The authors noticed that using these measures, the number of patients with DTC evaluated during the early months of the pandemic was only 15% less than that evaluated by in-ward examinations in the corresponding months of 2019.⁸

Thyroid nodules represent a prevalent finding, and the majority are benign. While the number of thyroid nodules detected is increasing, mortality remains stable. For this reason, a delay in their differential diagnosis is unlikely to affect the outcome in most of the patients negatively. FNA should be postponed except for patients with nodules with significant symptoms or signs of compression or patients with suspicion of medullary thyroid cancer.¹³ The same recommendations highlight the need for mandatory patient counselling and individual risk-benefit analysis before proceeding with diagnostic procedures, surgery, and RAI therapy for patients identified as candidates for urgent treatment.¹³

Neuroendocrine Tumors and PRRT

Some practical recommendations for managing patients with gastroenteropancreatic and thoracic NENs during the COVID-19 pandemic were developed by a multidisciplinary panel of experts from 12 high-volume NEN centers of expertise in 10 countries. Patients were advised to keep attending their referrals to centers of expertise for ongoing multidisciplinary supportive care. A proactive functional control was recommended to avoid hospitalization of patients with functional syndromes focusing on virtual or home assistance of the patients with adjustment of somatostatin analogues doses if necessary. Regarding PRRT specifically, the recommendation was made to consider COVID-19 testing of all patients before starting treatment and again after starting treatment when an infection is suspected.⁴⁰

From the COVINET survey by Panzuto et al, in Italy, the administration schedule was not modified in 85% of patients who had already started PRRT before disseminating SARS-CoV-2 began, whereas it was delayed in the remaining 15% of patients; no withdrawal occurred. Almost 25% of departments referred patients who were candidates to start PRRT to other centers, and 13% of centers referred to other centers patients who had already started PRRT. The respondents considered that the most frequent consequence of the pandemic was on the management of patients with NENs, with notable delays in diagnosing new cases (50%), starting treatments (37.7%), and follow-up examinations (26%).²²

Although patients who undergo PRRT can develop post-treatment lymphopenia, which is associated with a poor prognosis in the context of COVID-19 disease, there is no clear evidence that suggests a correlation between radionuclide therapy and a consequent increase in susceptibility to viral infections.^{41,42} Clinicians should nevertheless consider the possible consequences of postponing PRRT against the possible risk of a patient acquiring SARS-CoV-2 infection during radionuclide therapy.⁴¹ Delaying PRRT or modifying the timing or scheme of the treatment should be individually weighed against the possible risk of infection but may be considered in selected patients, for example, those presenting with grade III-IV neutropenia or lymphopenia or those with slow or no progression before treatment, low tumor burden and non-functional disease.⁴⁰ Particular attention should be paid to the prevalence of COVID-19 in the geographical area in which patients reside, as well as the comorbidities of the patients who will undergo radionuclide

therapy, focusing mainly on the possibility of pulmonary and renal complications.⁴² As in the other fields of NM, proper infection control measures should be employed, such as screening patients for the presence of respiratory symptoms or fever before admission and confining patients to one room during overnight admissions.⁴¹

Discussion

As a result of the COVID-19 pandemic, most European NM departments experienced modifications in their workflow, although only a few were closed or shifted their activity to assist COVID-19 patients.⁵ The worst-affected countries in terms of personnel infected with SARS-CoV-2 were Spain and Italy.³ However, almost every NM department in Europe continued its activity with a reduced workforce due to confirmed infections of personnel and also to other COVID-19-related causes, such as personnel with COVID-19-like symptoms but negative SARS-CoV-2 PCR swab tests, self-isolation because of family members with COVID-19 symptoms, and stress-related illness or burnout.⁶ Practical guidelines on the implementation of measures to limit the spread of SARS-CoV-2 infection were introduced, which covered environmental and personal hygiene, social distancing, high work performance, the use of PPE, and prompt identification of suspect COVID-19 cases^{4,9-11}; however, implementation did not come without issues. NM physicians reported a shortage of PPE, especially in the first phase of the pandemic.^{3,6,21} Social distancing and maintaining proper hygiene have caused a lengthening of the time needed for imaging procedures and the working day and a change in some examination protocols and reduced the number of patients seen and treated.^{5,7,21,30}

The pandemic resulted in a significant reduction in diagnostic and therapeutic NM procedures that may have reflected a reduced level of care for patients with diseases other than COVID-19, such as cancer or acute cardiovascular disease.^{5,41} Healthcare systems struggled to maintain the standard of care for these patients.^{43,44} Additionally, many patients avoided seeking medical care because of fear of becoming infected with the coronavirus while in the hospital. The reorganization of the healthcare service should preserve access to medical care and clinical trials through a balanced allocation of resources, personnel, and equipment.^{22,23,45,46}

Several recommendations from scientific societies (eg, the European Association of Nuclear Medicine, the Society of Nuclear Medicine and Molecular Imaging) and international organizations (eg, the International Atomic Energy Agency) have been published to support NM departments to face the COVID-19 pandemic. Several published reports have described the experience of single centers in reorganizing, reshaping their practice and refocusing their activities. These reports demonstrate that no emergency operational procedures and resources were available before SARS-CoV-2 spread both locally and globally. Leaders in the NM field now have the opportunity to develop guidelines/recommendations with dedicated leadership teams and allocate resources to be used in case of new possible challenging situations.^{47,48}

In addition to the impacts on clinical work, there were disruptions to the educational activities of NM physicians, residents and medical students. Teaching, practical training and research were affected by the pandemic,⁴⁹ and almost all on-site congresses and meetings were cancelled during 2020. However, communications technology allowed the reshaping of educational activities; indeed, webinars and virtual congresses became widely accepted and successful events.⁵⁰⁻⁵²

The COVID-19 pandemic has led to significant interest in and the adoption of technology-enabled virtual healthcare delivery. Telemedicine services have been set up all over the world to maintain medical assistance for patients. Despite initial difficulties in organizing these services, they could represent a helpful tool that should be maintained beyond the pandemic, especially for patients who have movement limitations or live in remote places and have difficulty reaching NM centers, at least for preliminary or follow-up pre-imaging evaluation.²⁸ Furthermore, telemedicine could represent a helpful tool to maintain for multidisciplinary meetings to achieve better patient management, alongside convenience for physicians regarding both organizational effort and the time required for such meetings. As the general population and healthcare providers become increasingly comfortable with videoconferencing due to the COVID-19 pandemic, it is expected that requests for virtual appointments will increase, technological barriers will decrease, and healthcare providers will increase their capabilities to provide 'virtual care'. The patient-physician relationship and patient assistance are expected to benefit from these technologies in the future considerably.

Conclusion

The COVID-19 pandemic has reshaped NM practice. Human resources, diagnostic and therapeutic management of patients, radiopharmaceutical supplies, teaching, training and research, were affected in NM departments across Europe. New operative models have been applied during the pandemic to prevent the spread of SARS-CoV-2, the agent of COVID-19 disease. Our duty as NM practitioners is to provide continuity in care, especially for more fragile patients, while maintaining infection control measures. The challenges that have been faced in the pandemic course so far should reshape our vision and help us prepare for the future.

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